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ABSTRACT

This document contains the following full and short papers on networked social learning from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction): (1)" A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community" (Brian Hudson, Ahmed El-Gamal, Amal Gouda, Eric Knutsen, Merja Ruotsalainen, Antti Peltonen, Minna Pesonen, and Tarja Tervola); (2) "Is a Learning Theory Harmonious with Others? To Form Effective Collaborative Learning Groups with Ontological Engineering" (Akiko Inaba, Thepchai Supnithi, Mitsuru Ikeda, Riichiro Mizoguchi, and Jun'ichi Toyoda); (3) "Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan" (Gin-Gon Nancy Ju); (4) "Online Education: A Learner-Centered Model with Constructivism" (Kam Hou Vat); (5) "Peer Help for Problem-Based Learning" (Susan Bull and Jim Greer); (6) "The Interactive Virtual Community" (Pen-Choug Sun, Chien-Chang Lee, Chun-Wen Hsu, Shower-Long Hong, and Jui-Chun Tai); and (7) "The Network Learning Supported by Constructivism" (Song-Min Ku). (MES)

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Proceedings

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A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community

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This paper outlines the background to the development of a European Masters programme in *Multimedia Education and Consultancy*. The development arises from an Advanced Curriculum Development (CDA) Project supported by the European Commission under the SOCRATES programme, which involves nine institutions in seven different European countries. The aims and outline of the Masters programme are described together with the pedagogical approach adopted. A key feature of the latter is a virtual learning environment that is underpinned by the use of the concept of "metaphor". This is intended to convey how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users. A pilot unit/module on *ICT in Open Learning Environments* is outlined together with some of the key features of the learning environment. This was trialled by a group of students based at locations in Finland, Austria, the Netherlands and the UK during the second semester of the academic year 1999-00. Evaluations are provided by a participating tutor, an observer and from two participating students. Finally some reflections are outlined which focus on the innovative aspects of this learning environment and of our experiences as teachers and learners in a multinational virtual learning community.

Keywords: **Collaborative Learning - Web-Based Learning - Networked Social Learning - Teaching and Learning Processes**

1 Introduction

This paper reports on experiences as teachers and learners in a multinational virtual learning community, which have resulted from our involvement in a pilot unit as part of the development of a European Masters

course. The pilot unit is entitled *ICT in Open Learning Environments* and our involvement has taken place between February and May 2000.

2 Background to the development

The background to the development is the Advanced Curriculum Development (CDA) Project *TRIPLE M: Masters in MultiMedia Education and Consulting* that is supported by the European Commission under the SOCRATES programme (29268-IC-2-97-1-AT-ERASMUS-CDA-1) over the period 1998 to 2001. The *TRIPLE M* project is co-ordinated by Pädagogische Akademie des Bundes in Österreich, Linz, Austria and involves a number of departments and research units with experience and expertise in teacher education and the use of Information and Communication Technology (ICT). The current participating institutions in the *TRIPLE M* project are:

- Pädagogische Akademie des Bundes in Österreich, Linz, Austria (Co-ordinating institution)
- Charles University, Prague, Czech Republic
- Hogeschool Arnhem and Nijmegen, Netherlands
- Liverpool Hope University College, United Kingdom
- Pädagogische Akademie Vienna, Austria
- Sheffield Hallam University, United Kingdom
- Umeå University, Sweden
- University of Oulu, Finland
- University of Santiago de Compostela, Spain

A sub-group of the TRIPLE M Consortium has formed the *European Association for Multimedia Education and Consultancy™ (EAMEC™)* with the intention of offering a validated Masters programme in for *Multimedia Education and Consultancy* from September 2000. Initially this will be offered as a part-time route with a plan to run the programme on a full-time basis from September 2001.

3 Programme aims and outline

The academic aims of the programme have been developed in response to the needs of the 'Information Society' phenomenon related to the rapid development of high technology use in all sectors of society. The programme aims to meet the needs of teachers in schools and further and higher education especially. Specifically the programme seeks to develop the profile of the 'problem solver'/team co-ordinator at the interface of pedagogical, technological and organisational/cultural dimensions of development. In summary the programme aims to support the development of individuals who are able to:

- demonstrate and communicate knowledge and critical understanding of pedagogical issues as applied to the use of multimedia in new learning environments
- critically understand the social, organisational and cross-cultural phenomena related to new learning environments in trans-national and cross-cultural contexts
- appreciate and be responsive to the social and cultural impact of the Information Society in relation to values and working practices
- act as effective mediators and facilitators at the interface between the needs of users and providers
- co-ordinate the efforts of multi-disciplinary teams in terms of problem analysis, design and implementation issues
- be aware of the staff development needs of new users and appreciate the support structures and strategies for continuing development
- demonstrate a critical understanding of (educational) research and its role in a context of rapid change
- remain open to critiques of the Information Society with particular regard to the social and cultural implications

The programme is made up of six units/modules that together make up 90 European Credits (ECTS). These are as follows:

- Open Learning Environments (*OLE* - 10 ECTS)
- Digital Media Applications (*DMA* - 10 ECTS)
- Communication and Consultancy (*CC* - 10 ECTS)
- Research Methodolgies (*RM* - 10 ECTS)

- Project Studies (*PS* - 20 ECTS)
- Dissertation (*DS* - 30 ECTS)

The four more structured units (OLE, DMA, CC and RM) all follow a common pattern of:

- Telematic-based Studies (50%) e.g. Web-based work and discussions, multi-point videoconferencing sessions, and
- Local and Independent Studies (50%) in national groups e.g. day workshops and tutorials plus independent study.

4 Pedagogical approach

The pedagogical approach involves Telematic-based Studies in Web-based work, discussions and multi-point videoconferencing sessions in multinational learning communities. It is seen as crucial that these studies are supported by Local Studies - in national groups e.g. day workshops, practical activity, project work, research activity and tutorials and Independent Studies including literature reviews, independent project work, research activity, writing etc.

The use of ICT as a medium for learning and communication is fundamental to the underpinning philosophy of the programme and is an integrated and all pervasive aspect of the pedagogical approach, both in terms of learning about it and as an essential part of the learning process. Students need to use the Internet as an essential part of the learning and communication process.

The platform for the net-based learning environment is *LC Profiler – Learning Community Profiler*. This is the product of *LCProf Oy*, which is a Learning Service Provider (LSP) and a 'spin-off' company of the University of Oulu. The services are based on the methodology and system developed at the University of Oulu in a range of domestic and EU R&D and education projects during the last 5 years (e.g. Telematics projects T3: Telematics for Teacher Training, SCHEMA: Social Cohesion through Higher Education in Marginal Areas). The implementation of the system is based on the principle of creating a distributed community of learners and supporting the tutors to enable them to create their own learning communities. This means that the tutors also belong to a unique learning community of their own, which aims to support ongoing professional development.

5 The role of metaphor

The concept of metaphor plays a fundamental part in the underlying design of the *LC Profiler* environment and also in signifying key functions to the user. In their paper Pulkinnen and Peltonen [1] use the concept of "metaphor" to "explain how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users". This paper is also one of the Core Readings for all students on the OLE unit/module. Their analysis combines ideas about knowledge, the structure of knowledge and learning with social aspects to do with the organisation of learning such as practical arrangements connected with "time, place and repetitive rituals". Their overall metaphor which captures the nature of the *LC Profiler* environment is of "a place of studying (virtual space) created with the help of ICT". The three "cornerstones" of their analysis of the learning environment are the individual whether as teacher or learner, the technology and the culture as fully outlined in Pulkkinen and Ruotsalainen [2]. They describe these as providing the "cross-disciplinary basis for the elements that are necessary for learning" and identify these elements as pedagogical functions, appropriate technologies, and the social organisation of education

6 The pilot unit/module

As part of the curriculum development process, two units have been piloted during the period from February to May 2000. These are *ICT in Open Learning Environments* (February to May) and *Digital Media Applications* (March to May). The former is based on an existing unit/module at the University of Oulu and forms the model for the development of the Masters programme as a whole. The full unit/module is worth 10 ECTS M Level credits for which 5 ECTS is available for successful completion of the telematics-based component. This was trialled as part of the TRIPLE M project with a group of about 25 Finnish, 9 Austrian, 4 Dutch and 2 UK students

The course outline is seen as one of the most important navigation tools, referred to as an "orientation metaphor". The introductory screen is shown below in Fig 1.

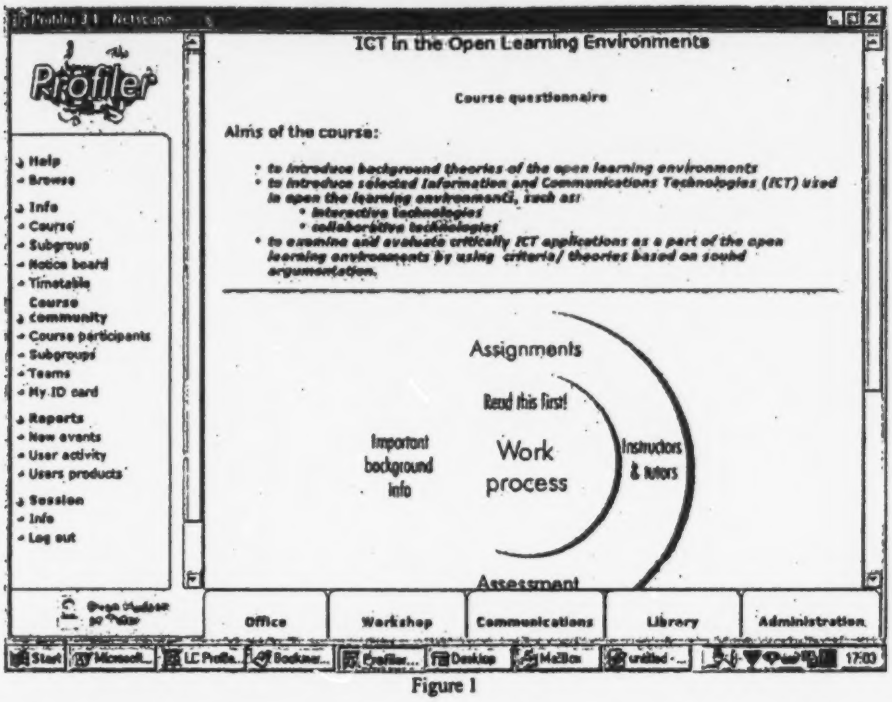

Figure 1

This screen includes a statement of the aims of the course and also conveys some of the metaphors that underpin the design of the system. (NB The use of the term "course" here is equivalent to the terms "unit/module" used previously and is a reflection of the diversity of the use of these descriptors across and within different systems) The most apparent metaphors are those which are to do with orientation to place or virtual working place. The Project Office, Workshop, Communications Centre, Library and Administration Centre refer to "working" and not to the technology and tools being used e.g. e-mail, chat, documents etc. This aspect is seen to be a particularly important issue in relation to signifying metaphors to users that refer to pedagogical practices. The metaphor of "project" is used to convey "the basic essence of learning" and the course flow orientates the user to time. This includes phases on the work process e.g. orientation, planning etc and also milestones, which are outlined in part in Figure 2.

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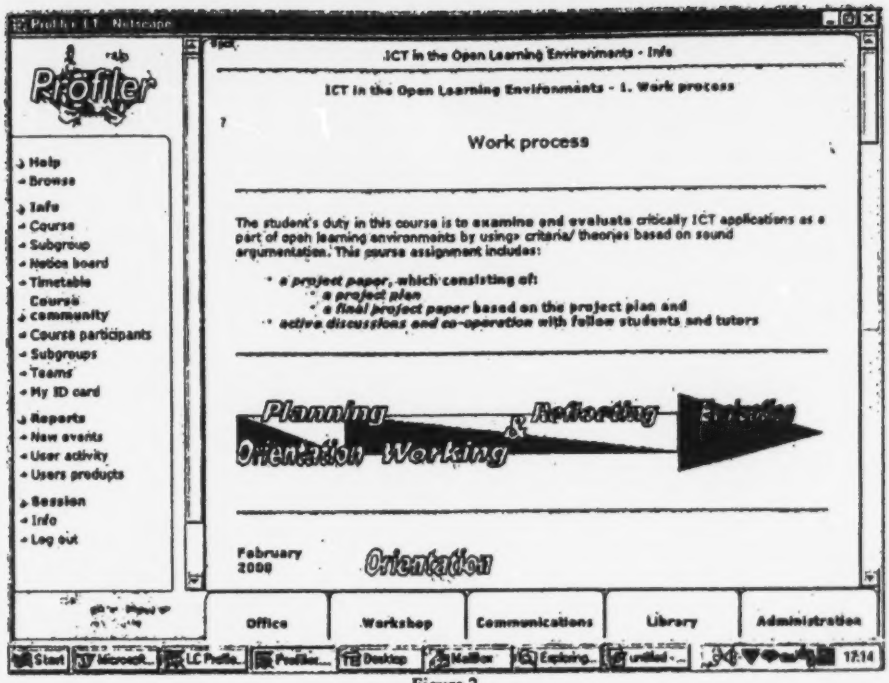

Figure 2

7 Experiences as teachers and learners

This section includes accounts and evaluations from a participating tutor (Brian Hudson), an observer (Ahmed El-Gamal) and from two participating students (Eric Knutsen and Amal Gouda).

As a particpating tutor I was immediately struck by the very clear sense of purpose that the course outline engendered with a very clear sense of the different phases, mileatones and overall timescale. The active participation in discussions was not an option but a necessary requirement with comments being expected within fixed timescales and core readings, project plans of peers etc. As a result the level of communication on the course was very high - an analogy might be made with lighting a wood and coal fire - a little slow at the start but then bursting into flames from all sides!

Another key observation was of the role of the two main moderating tutors. Both could be characterised as being "on task" throughout the course of the unit/module. In general their responses to questions were very swift and they dealt with technical, pedagogical and social issues. The two tutors also interacted with each other in a very effective way by following up on each others comments, questions and prompts - so engendering a relaxed yet lively ambience around the discussions.

An example of the extent of the student discussions can be gleaned from the screen in Figure 3 below:

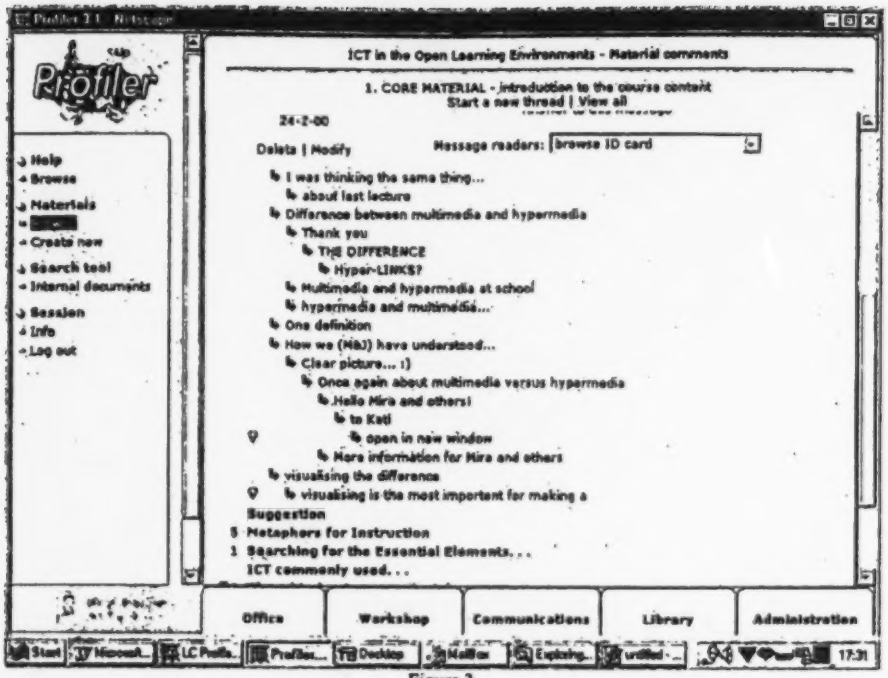

Figure 3

The particular thread started outlined above was started by student H on 24-02-00 with the comment:

Could some of you tell me what is the difference between multi- and hypermedia? Is there any difference, do they mean the same thing? The difference between these "words" was explained in the first core text but I just couldn't find the basic idea which might help to separate them.

These questions resulted in a rich, intense and well-informed discussion with around twenty contributions over a ten-day period, which seemed to conclude in an agreed consensus. Overall discussions were by no means restricted to technical matters but this particular thread was notable for its richness and intensity. A notable feature of this environment is the very clear way in which the threads are laid out and also the way in which the links are revealed when a thread such as the one above is opened.

Ahmed El-Gamal had the role of being a Local Tutor and was given access to *LC Profiler* as an observer. He is a staff member of Menofia University in Egypt on a PhD scholarship supported by the Egyptian Ministry of Education and Culture. He has chosen to cluster his comments around characteristics that he noticed about the learning environment in overall terms. This is a summary of his comments on these charactersitics:

Organization: The whole unit is well organized e.g. timetable, assignments, activities..etc. If there is any misunderstanding the student can post a question to the others.

Adaptability:Most of students adapted easily with this learning environment. Sometimes they have some technical problems e.g. the speed and the difficulty in using some tools, but they soon found assistace from the tutors and their peers.
Flexibility:It is a very flexible learning environment - students worked at different times in different countries, yet they have the opportunity to discuss the same topics.
Some students from different countries were able to create teams to conduct the same project.

Collaboration: Students collaborated with each other in solving some technical problems, clarifying some aspects in the references, developing teams and developing their project plans.

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Conversation and discussion: Students were discussing different issues that were relevant to the course. All the participants have the opportunity to contribute to the discussion. They wouldn't end the discussion until they reached an agreement about the topic e.g. the discussion about the difference between Multimedia and Hypermedia was about 20 comments.

Social interactivity: Most of students have some social interactivity, by talking to the other students in the on-line café and by posting messages. Some friendships have been developed during the course.

Amal Gouda has studied to Diploma level in Educational Technology at Cairo University and is continuing her Masters studies at this time. She has chosen to group her evaluation around features of the studying process:

The studying process in OLE could be defined as an integrated process, which integrates the different resources and the different parts of the OLE to achieve the desired goals. The studying process in OLE is accomplished through the following parts:

Office: Every student can manage almost all his/her study through using the office and all the information about the course and other students are available on the office, in addition to the timetable and the framework of the course.

Workshop: Every student has developed his/her project plan and he/she has published it to the other course participants. This gave his/her opportunity to have the other students comments on it.

Communications: It gave the international students the opportunity to freely discuss different topics related to the course. It also allows them to discuss their project plans and the other students' project plans. Moreover, there are different categories for discussion e.g. questions and urgent message, general discussion about the study process..etc. In online café, the students can have a social chat with their peers.

Library: It has most of references that are related to the course, also it has a hyperlinks to enable students from browsing more materials. It was advised to write comments on these materials, in order to encourage the students to read them carefully.

Local studies: Every student met with his/her tutor many times to discuss the different topics and activities that seem to be unclear and to guide him/her through the course. The most important feature in the studying process in OLE is that it gave the opportunity to study and discuss different topics at any time during the day.

Eric Knutsen works in a secondary school and is in his first year of teaching as a teacher of ICT. He has chosen to respond to the aims of the course and to evaluate the extent to which these were met for him as a student:

- to introduce background theories of the open learning environments

This was done in a straightforward manner utilising the OLE of LC Profiler. It was useable as one would use a library in the traditional environment of a physical learning environment. The added value here was the amount of material referenced via the web. Using the expertise of the instructors on the course, I was able to make use of the varied written material and discuss other students' and my own opinions on the content. Being done in an asynchronous way, there was no need to be present physically or virtually for such discussion. Yet, I had the advantage of dozens of other opinions from which to draw my own conclusions. This took my learning beyond that previously possible via ..traditional learning ...

- to introduce selected (ICT) Information and Communications Technologies used in open learning environments, such as interactive technologies and collaborative technologies

One aspect of having been introduced to the background theory in the way it was done is the ability to review tens of project proposals and final project papers in light of the theory examined. This made the theoretical come to life, especially when undertaking my own individual work. This meant looking critically at the variety of components comprised with-in the environment being examined ...What made this a more lively introduction to the ICT was the regular use of LC Profiler and the success of the discussions taking place.

- to examine and evaluate critically ICT applications as a part of the open learning environments

by using criteria/ theories based on sound argumentation

Given the foundation above ... it was straightforward to see the relevance of the theory when examining the OLE at hand. Especially of interest was the use made of LC Profiler as an OLE by all members of the course and the social interaction made possible by all areas of LC Profiler, not isolated to the on-line cafe. This even fed the theoretical side to my thoughts about my assignment.

8 Conclusions

The experience of participating in this pilot unit has provided a real example of the transformative potential of the use of ICT. This is in spite of several years experience of using the *First Class* conferencing software which seems quite limited by comparison with *LC Profiler*. In McConnell's [3] terms *First Class* can be seen to be simply an example of "unstructured groupware" or an "electronic space". Some experiences result in real and lasting changes - for myself this experience has transformed my own pedagogical thinking and practice. Whilst being a vital component, the learning environment of itself is not the main ingredient for experiencing this transformation, although many people at this time are looking for the "quick fix" and simple solutions. However it has been the experience as a participant in a community of practice (Hudson [4]; Lave, [5] and Lave and Wenger, [6]) that has been fundamental. This process takes time and is about changes within (the person) and developing new ways of relating to other people. In general terms such high levels of on-line communication also necessitate the need to develop a more relaxed attitude towards committing ideas into print, for seeing such comments as transient and not permanent and being accepting of the need for "repairs" to communication as one would in more traditional forms of communication.

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Is a Learning Theory Harmonious with Others?

To form Effective Collaborative Learning Groups with Ontological Engineering

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Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. In this paper, we describe the outline of a system of concepts concerning learning goals expected to attain by learners through collaborative learning process with justification by the learning theories. We propose possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

Keywords: **Ontology, Collaborative Learning, Distributed Learning Environments**

1 Introduction

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. To fulfill these objectives, we have to consider the following:

1. How to detect the appropriate situation to start a collaborative learning session and to set up the learning goal,
2. How to form an effective group which ensures educational benefits to the members of the group, and
3. How to facilitate desired interaction among learners in the learning group.

We have discussed item 1 in our previous papers[10, 11], and this paper focuses on item 2. When we have clarified item 2 and extracted the desired interaction in the group, we would consider item 3.

There are many theories to support the advantage of collaborative learning. For instance, Observational learning[2], Constructivism[19], Self-regulated learning[9], Situated learning[15, 16], Cognitive apprenticeship[5], Distributed cognition[21], Cognitive flexibility theory[22, 23], Sociocultural Theory[25, 26], Zone of proximal development[25, 26], and so on. If we select a theory from these and form a learning group based on the theory, we can expect effective collaborative learning with the strong support of the theory. However, it is difficult to understand all theories because these theories are derived from a wide research area including pedagogy, sociology and psychology. Moreover, we can expect different educational benefits based on these learning theories, and observe various kinds of interaction between learners through collaborative learning process. Due to the diversity, it is difficult to list the learning theories effective to gain a specific educational benefit for a learner, and to compare the theories to form a suitable collaborative learning group for the learner.

Therefore, we have been constructing a system of concepts to represent collaborative learning sessions supported by these learning theories[12, 14, 24]. We call the system of concepts "Collaborative Learning Ontology". Although advantages of collaborative learning over individual learning are well known, the collaborative learning is not always effective for a learner. Educational benefit that a learner gets through the collaborative learning process depends mainly on interaction among learners. The interaction is partly influenced by relations among members of learning group, which suggests that how to form an effective group for the collaborative learning is critical to ensure educational benefit to the members. In this paper, we focus on "Learning Goal Ontology" which is a part of the Collaborative Learning Ontology.

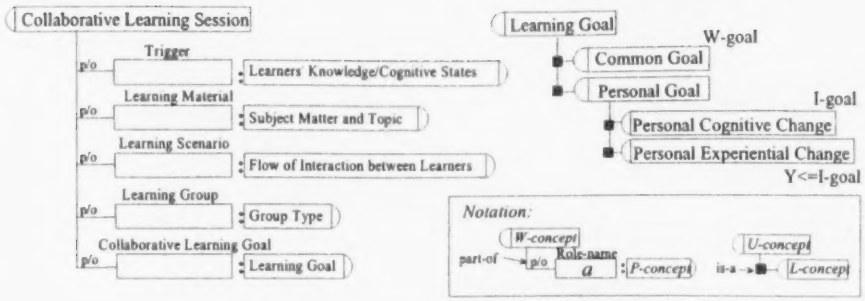

Fig. 1. Collaborative Learning Ontology

The concept "Learning Goal" is one of the most important concepts for forming a learning group because each learner joins in a collaborative learning session to attain some learning goals.

To help a learner obtain a specific educational benefit we can find several learning theories useful for the purpose and form different learning groups according to the theories. If the groups are merged into one, we may form a better learning group which is guaranteed its effectiveness by multiple learning theories. So, we also discuss the combination of learning groups supported by different learning theories.

This paper is organized as follows: we first show briefly the structure of our "Collaborative Learning Ontology" and "Learning Goal Ontology". Then we summarize advantages and remaining tasks: how can we narrow down candidates of learning groups into one? Finally we propose a new learning group formation formed by combining multiple learning theories.

2 Learning Goal Ontology for Collaborative Learning

Through a survey of studies on collaborative learning, we picked up concepts to represent a collaborative learning session. As a result, we set up five primitive concepts to characterize the session: Trigger, Learning Material, Learning Scenario, Learning Group, and Learning Goal. Fig. 1 shows the conceptual structure of Collaborative Learning Ontology.[1] Here, we concentrate on the concept"Learning Goal" which is one of the most important concepts for forming a learning group, because each learner joins in a collaborative learning session to attain some learning goals. The "Learning Goal" can be specified as two kinds of goals: "common goal" as a whole group and "personal goal" for each learner. The concept "personal goal" can be specified as two kinds: the goal represented as a change of a learner's knowledge/ cognitive states, and the goal attained by interaction with other learners.

We classify the goal of the first person (*I*), that of the first person to interact with the second person (*You*), and that of the whole group as I-goal, Y⇐I-goal, and W-goal, respectively. I-goal, which is described as G:I, represents what a learner is expected to acquire. Y⇐I-goal, which is described as G:Y⇐I, represents what a learner is expected to acquire through the interaction. W-goal expresses the situation being set up to attain Y⇐I-goals and we describe the goal as G:W. W-goal is a common goal characterizing the whole group.

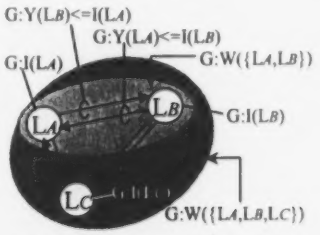

Fig. 2. Learning Goal Ontology

Fig. 2 represents learning goals in a group where three learners: L_A, $L_B$and $L_C$are participating. Learner $L_A$has an I-goal which is attained through this collaborative learning session and this goal is described in Fig. 2 as G:I(L_A). Both $L_B$and $L_C$have I-goals, and they are represented as G:I(L_B) and G:I(L_C) respectively. G:Y(L_B)⇐I(L_A) is a Y⇐I-goal between $L_A$and $L_B$observed from L_A's viewpoint. In other words, it means the reason why $L_A$interacts with L_B. Concerning this interaction between $L_A$and L_B, there is also a Y⇐I-goal observed from L_B's viewpoint. That is, it is the reason why $L_B$interacts with L_A. This Y⇐I-goal is represented as G:Y(L_A)⇐I(L_B). Both G:I(L_A) and G:Y(L_B)⇐I(L_A) are personal goals of

[1] Notation: the schemata define the W-concept and the U-concept. The W-concept has entity a, which is an instance of the concept P-concept, as a part. The entity a plays a specific role (Role-name) in the W-concept. The concept P-concept has a semicircle on the right sides. It means the concept is defined in other schema. The L-concept is a specification of the U-concept, and the U-concept is a generalization of the L-concept.

Table 1. W-goals

		W-goal	Definition	Src.
Singleton W-goal	M-P x S-S	Setting up the situation for Peer Tutoring [PT]	Setting up the situation where a learner teaches something to another learner.	[6, 7]
		Setting up the situation for Anchored Instruction [AI]	Setting up the situation where a learner diagnoses another learner's problem and then solve it (Problem-based Learning)	[4]
	S-P x M-S	Setting up the situation for learning by Cognitive Apprenticeship [CA]	Setting up the situation to learn knowledge or skill as an apprentice	[5]
		Setting up the situation for sharing (Meta-) Cognitive function between learners [SC]	Setting up the situation to share cognitive or meta-cognitive function between learners based on Sociocultural Theory	[25, 26]
		Setting up the situation for sharing Multiple Perspectives [CF]	Setting up the situation to evoke a learner's reflective thinking based on Cognitive Flexibility theory.	[22, 23]
	M-P x N-S	Setting up the situation based on Distributed Cognition [DC]	Setting up the situation where full participants, whom knowledge bases are different each other, discuss problems	[21]
		Setting up the situation based on Cognitive Constructivism [CC]	Setting up the situation where full participants discuss problems	[19]
CW-goal		Setting up the community for Legitimate Peripheral Participation [LPP]	Setting up the the community of practice for peripheral participant	[15, 16]
		Setting up the situation for Observational Learning [OL]	Setting up the situation to share other learners' learning processes	[2]

Note: [**] means an abbreviation for the W-goal.
e.g., The W-goal "Setting up the situation for Peer Tutoring" is abbreviated as "PT".

L_A. G:W($\{L_A, L_B\}$) is a W-goal of the learning group ($\{L_A, L_B\}$). G:W($\{L_A, L_B, L_C\}$) is a W-goal of the learning group ($\{L_A, L_B, L_C\}$).

We have identified goals for collaborative learning for each of the three categories, and constructed I-goal Ontology, Y⇐I-goal Ontology, and W-goal Ontology with justification based on learning theories.[2] We can expect learners to acquire not only new knowledge concerning problems they solve, but also cognitive skills, meta-cognitive skills, and skills for self-expression through the collaborative learning session (I-goals). Each I-goal has several phases of development. It is difficult to understand from a theory what educational benefit is expected to a learner, because of lack of unified systematic terminology to represent a variety of phases. So, we adopt the terminologies used in two established findings: Rumelhart & Noman's work[15] on knowledge acquisition and Anderson's one[1] for skill development. The process to acquire a specific knowledge includes three qualitatively different kinds of learning[15]: Accretion, Tuning, and Restructuring. Concerning development of skills, there are also three phases of learning: Cognitive stage, Associative stage, and Autonomous stage[1, 8].

The learner is expected to achieve these I-goals through interaction with other learners. For example, to achieve the I-goal "Acquisition of Content-Specific Knowledge (Accretion)", some learners could take the Y⇐I-goal "Learning by being Taught[5]", while some learners could take another Y⇐I-goal "Learning by Observation[2]".

Table 1 shows the W-goals. The W-goals are classified into four kinds (*i.e.*,Three kinds of singleton W-goals and one Composite W-goal) according to their structures. To form a learning group means to pick up learners who join in the group as members and to assign a specific role in the group to each member. The formation should have rationale supported by learning theories. The structure of learning goals expresses the rationality. A W-goal, which is a learning goal as a whole group, provides the rationale for the interaction among the members. It means that a W-goal specifies a rational arrangement of Y⇐I-goals. Fig. 3 shows a typical representation for the structure of a W-goal. It would be more easily to understand a learning theory by preparing the structure to represent the theory and filling in each component of the structure with suitable concepts according to the theory.

A learning theory generally argues the process that learners, who play a specific role, can obtain educational benefits through interaction with other learners who play other roles. The theories have common characteristics to argue effectiveness of a learning process focusing on a specific role of learners. So, we represent the focus in the theories as Primary Focus and Secondary Focus.

Primary Focus (P): a learner's role that is mainly focused in the learning theory. The learner who plays this role (P-member) is expected to gain the main educational benefit.

[2] The details of the ontologies are described in our previous paper[14]. Here, we show the outline of the ontologies.

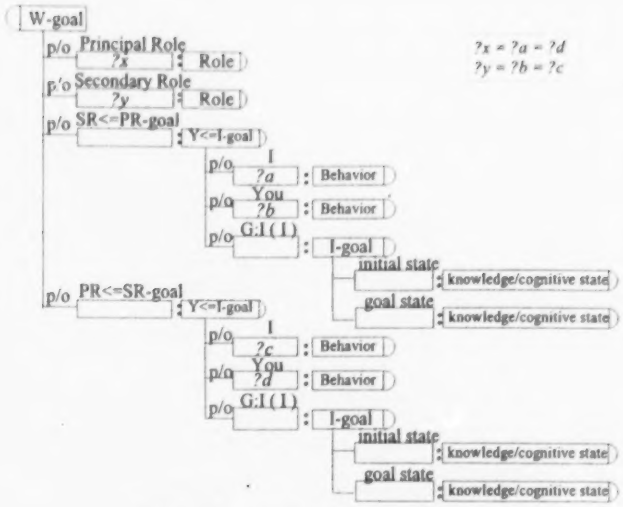

Fig. 3. Conceptual Structure of a W-goal

Secondary Focus (S): a learner's role that is weakly focused in the learning theory. The learner who plays this role (S-member) is needed as a companion to enable a P-member to attain his/her learning goals.

We classify the W-goals into the following four kinds depending on the number of the components P and S.

Singleton W-goal: Each Singleton W-goal can exist independently.

Multiple-P x Single-S: The W-goal of M-P x S-S type can have multiple P-members and single S-member.

Single-P x Multiple-S: The W-goal of S-P x M-S type can have single P-member and multiple S-members.

Multiple-P x No-S: The W-goal of M-P x N-S type has only one role for its members. In this group, each learner plays a role of companion for the other learner, while he/she gains main educational benefit.

Composite W-goal: The CW-goal includes another group as its component S.

For example, in the situation of Peer Tutoring, there are two roles: *Peer Tutor* and *Peer Tutee*. Main educational benefit is tuning of content-specific knowledge by externalizing a learner's knowledge[6, 7]. So, P is identified as *Peer Tutor* and S is identified as *Peer Tutee*. From the viewpoint of assigned task, the role of main problem-solver is *Peer Tutee* who wants to get a new knowledge to perform assigned tasks, while the role of helper is *Peer Tutor*. The number of members who play *Peer Tutee* (S) should be single, the number of members who play *Peer Tutor* (P) can be multiple, and the W-goal **PT** is identified as a M-P x S-S type.

A group attaining a W-goal(W_i) can have another group, which has another W-goal(W_j), as the component S of the W-goal(W_i). We call the W-goal(W_i) "**CW-goal**" which means a composite W-goal. Fig. 4 shows the conceptual structure of the CW-goal Observational Learning[2]. The learning group has *Observers* as its component P.

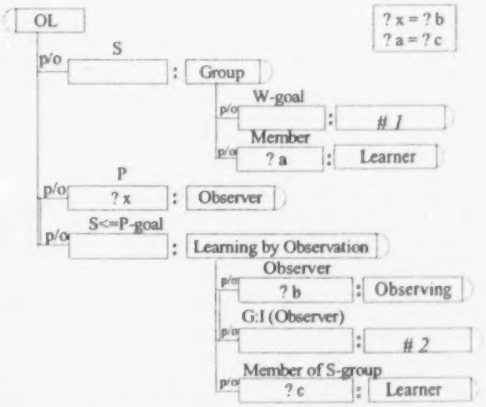

Fig. 4. An Example of CW-goal: OL

The *Observers* require a group (*i.e.*,its component S) as an object to observe meaningful interaction. In the figure, the W-goal, which is set in #1, depends on what I-goal is set in #2. For example, if accretion of content-specific knowledge is set in #2 as *Observer*'s I-goal, the W-goal **PT** is recommended as S's W-goal (#1).

A W-goal has two kinds of goals of interaction as follows:

S⇐P-goal: a Y⇐I-goal which means how and for what purpose the P-member interacts with the S-member.

P⇐S-goal: a Y⇐I-goal which means how and for what purpose the S-member interacts with the P-member. In the collaborative learning session, all members of learning group are expected to get some educational benefits. So, the S-member also has an I-goal, and the P⇐S-goal should be effective to attain the I-goal.

The entities of these goals refer to the concepts defined in the Y⇐I-goal Ontology. The conditions, which are proper to each W-goal, can be added to the concepts, if necessary. Each of the Y⇐I-goals referred to by S⇐P-goal and P⇐S-goal consists of three components as follows:

I: a role to attain the Y⇐I-goal. A member who plays I role (I-member) is expected to attain his/her I-goal by attaining the Y⇐I-goal.
You: a role as a partner for the I-member.
G:I: an I-goal which means what the I-member attains.

Each W-goal can be expressed by a set of Y⇐I-goals and I-goals. We can identify a group formation to start an effective collaborative learning session with these goals.

3 Advantages and Remaining Tasks of Learning Goal Ontology for Forming an Effective Learning Group

In a traditional classroom, sometimes a teacher divides students into several subgroups, and then the students start collaborative learning in the subgroup all at once. Such collaborative learning does not ensure educational benefits for every student, because it depends on a student's knowledge/ cognitive state whether collaborative learning is effective or not, and progress in learning differs from student to student.

So, we have been proposing a network-based new learning environment to support individual learning and collaborative learning dynamically. In the environment, each learner is solving problems individually with an ITS. When the ITS detects a desired situation for a learner (triggered-learner) to shift from individual learning mode to collaborative learning mode, the ITS forms an effective learning group for the learner, and then the members of the group start a collaborative learning session. In the group, not triggered-learner but every member should be ensured to attain individual learning goals through specific interaction with the other members. To encourage the interaction, every member is assigned a specific role in the group. When the members attain their learning goals, they close the session and return individual learning mode. We call the idea of dynamic group formation *"Opportunistic Group Formation (OGF)"*.

With our Learning Goal Ontology we can represent the several group formations whose effectiveness is ensured by learning theories. It means that the ontology brings the following benefit: When a personal goal for a learner (*i.e.*,I-goal or Y⇐I-goal) is decided, we can identify learning theories which propose learning groups to facilitate that the learner attain the personal goal. And then, we can form a specific group and identify roles assigned to the members of the group according to the theory.

If there are many theories to enable a learner to attain a specific personal goal, we can form many learning groups supported by the theories as candidates. Then, we have to narrow down the candidates to one. How can we select one?

Each learner plays a specific role in collaborative learning session. Every role has necessary conditions which should be satisfied by a learner who plays the role. The conditions will work as constraints to narrow down the candidates. If there are still some candidates after checking the conditions for role assignment, there are no rules for conflict resolution between all possible learning theories.

One might want to select one of the most profitable theory-based learning groups for a learner to attain a personal goal. Every theory expresses a different learning situation. The differences between theories do not mean the differences of the degree of effectiveness, but diversity of means to attain a goal. So, it is hard to compare a theory with the others on the effectiveness for helping a learner attain a personal goal.

There is another solution of the problem for narrowing down the candidates to one. Are learning theories exclusive each other? If the candidates can be integrated into one, a stronger learning group will appear: a learner is expected to attain a personal learning goal through some kinds of interaction, and each interaction is justified by a learning theory.

4 Is a Learning Theory Exclusive or Harmonious with Other Theories?

In actual learning environment, teachers often adopt the style of collaborative learning. If the group includes a member $L_A$whose knowledge base and/or experiences are relatively poor, it would be difficult for $L_A$to discuss with other members and to solve a problem collaboratively. $L_A$is expected to grow into a senior through practice in the group. This type of learning group is similar to the group based on the theory "LPP" which describes a process in which a newcomer grows into a senior[15, 16]. Fig. 5 shows typical learning group formation the W-goal "LPP" where three learners: L_A, $L_B$and $L_C$are participating. As a whole group, all members solve a problem collaboratively, and $L_A$is regarded as a **Peripheral Participant** and $\{L_B$and $L_C\}$ are regarded as **Full Participants.**

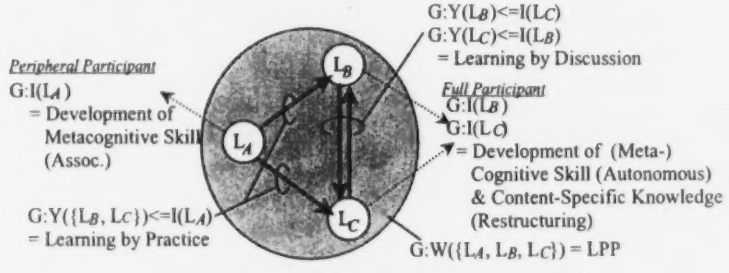

Fig. 5. An Example of Group Formation: LPP

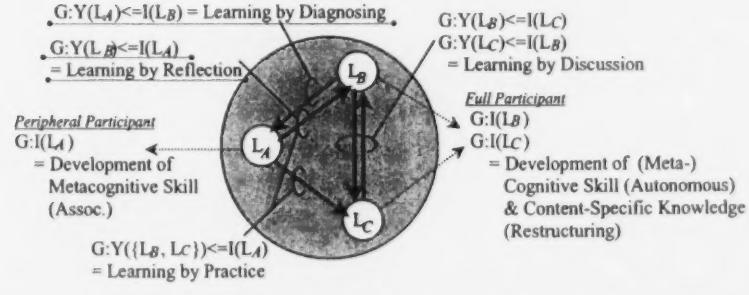

Fig. 6. An Example of Actual Learning Group

In this case, many skillful teachers will arrange for an excellent learner (*e.g.*,L_B) to help $L_A$in the group. For example, when a new student comes to our laboratory, a senior student may work as a tutor for the new student. Fig. 6 shows this type of learning group formation. We can find additional Y⇐I-goals between $L_A$and $L_B$in Fig. 6 as compared with Fig. 5. The teacher will expect different types of interaction between $L_A$and L_B, which bring additional educational benefits to them. This type of group formation can not be interpreted by a single learning theory.

In a learning group supported by "LPP", can all Peripheral Participants grow up into full participants? According to the theory "LPP", a learner (*i.e.*,Peripheral Participant) can acquire knowledge on the community and develop his/her (meta-) cognitive skills only by the learner's own practice. It is not assumed the other learners (*i.e.*,Full Participants) help the Peripheral Participant grows up. It seems that there is a gap between the Peripheral Participant and the Full Participant. Especially concerning the development of (meta-) cognitive skills, a Peripheral Participant can observe not the process in which

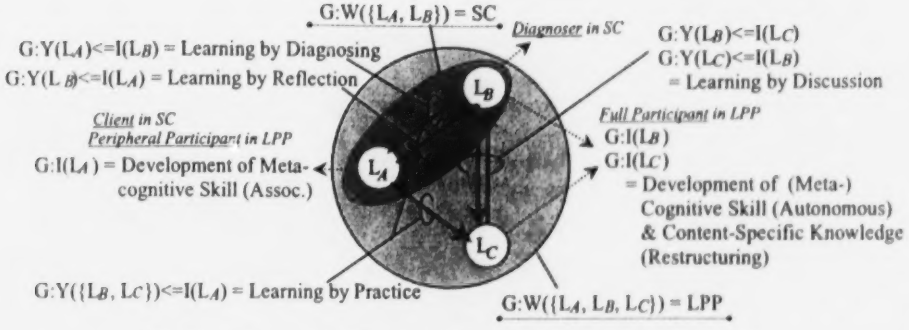
G:W({L_A, L_B}) = SC
Diagnoser in SC
G:Y(L_A)<=I(L_B) = Learning by Diagnosing
G:Y(L_B)<=I(L_A) = Learning by Reflection
G:Y(L_B)<=I(L_C)
G:Y(L_C)<=I(L_B)
= Learning by Discussion
Client in SC
Peripheral Participant in LPP
G:I(L_A) = Development of Meta-cognitive Skill (Assoc.)
Full Participant in LPP
G:I(L_B)
G:I(L_C)
= Development of (Meta-) Cognitive Skill (Autonomous) & Content-Specific Knowledge (Restructuring)
G:Y({L_B, L_C})<=I(L_A) = Learning by Practice
G:W({L_A, L_B, L_C}) = LPP

Fig. 7. An Example of Combined Learning Group: W-goal LPP & SC

a Full Participant uses the skill, but input and output for using the skill. It is difficult to learn the process by observing only input and output.

Concerning the W-goals, both W-goals "AI"[4] and "SC"[26] assume to have a "poor learner" who engages to solve a problem and a "helper" for the learner. The W-goal "AI" has a **Problem-Holder**, who has a difficulty in solving a problem, and an **Anchored Instructor**, who diagnoses the Problem-Holder's problem and gives advice to him/her. Similarly, the W-goal "SC" has a **Client**, who externalizes his/her own thinking process, and a **Diagnoser**, who diagnoses the Client's thinking process and evaluates the process. In both W-goals, a "poor learner" is expected to attain his/her I-goal, by a "helper"'s advice. Each of these W-goals can be combined with one of the other W-goals. That is, if it is difficult for a learner to attain an I-goal, we can combine the W-goal "AI" or "SC", and one of the other W-goals to help the learner attain the I-goal.

In the case of Fig. 6, we can interpret the group as a combination of two groups. One group ($Group_i$) consists of two Full Participants ($L_B$and L_C) and one Peripheral Participant (L_A). The W-goal of $Group_i$ is "LPP". Another group ($Group_j$) consists of a Client (L_A) and a Diagnoser (L_B), and the W-goal of the group is "SC". Fig. 7 shows the combination of two groups. In this learning group, $L_A$is expected to participate in the session more easily thanks to the help of L_B. For L_B, it is an opportunity for diagnosing L_A's authentic problems and helping $L_A$to participate in the collaborative learning session. Through the experience, we can expect $L_B$to develop his/her cognitive skill in two ways. For L_C, he/she will be able to get the same educational benefit with participating in the group shown in Fig. 5, because his/her activity is equal between the both groups.

For the combination of theory-based learning groups, the role of ontology is to clarify principles of combination. In combined groups, it should be guaranteed that all members can attain their own learning goals. At this stage, we store possible patterns of combining some theory-based learning groups as a pattern library. The ontology should not only represent the patterns, but also the principles which express the design rationale why the groups can be combined into one. When we can clarify the principles, an intelligent educational support system will be able to infer an effective learning group formation based on the principles opportunistically: The group formation is not picking up an appropriate one from the static pattern library. In this paper, we have described the possibility of combination the W-goal "AI" or "SC", and other W-goals. We have to consider the other types of combination.

5 Conclusions

We have discussed Learning Goal Ontology which will be able to make it easier to form an effective collaborative learning setting and to analyze the educational functions for a learning group. By considering the personal and common goals, we have identified three kinds of learning goals; I-goal, Y⇐I-goal and W-goal. In this paper, we described the outline of Learning Goal Ontology, and summarized advantages and remaining tasks for the ontology. We proposed possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

At this stage, we mainly focus on the learning goals. Future work includes to construct ontologies on remaining concepts in Collaborative Learning Ontology. Advantage of collaborative learning includes emotional factors: *e.g.*,motivation, familiarity. It is also our future work how to treat these factors.

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Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan

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This research was to investigate the current situation of computer network usage, frequency and purposes between university students and occupational groups in Taiwan. The research also analyzed the influences of its related factors on computer network usage, such as computer experience background, the attitudes toward computers, personality, aptitudes, critical thinking ability, academic achievement and so on. The subjects of university students were sampled from the Soochow University. The subjects of occupational groups were sampled from various occupations. The Computer Experience Background Scale and the Computer Attitude Scale were conducted by author for this research. Lai' s Personality Scale, Differential Aptitude Tests and Critical Thinking Appraisal are three published tests selected appropriately by the author and used for the research purposes. Academic achievement in the research was based on the students GPA.

According to the computer network usage of university students, 150 students were sampled in 1997. The network usage was classified into three types of purposes: (1) information searching, (2) BBS, (3) e-mail. The findings were that the students used computer network for searching information the most frequently, then for BBS, for e-mail the least frequently. Besides, the male students significantly used computer network more frequently than the female students, especially for the usage of information searching and e-mail purposes. About computer experience background and the attitudes toward computers, the students who have more computer experience background and who have more positive attitudes toward computers significantly used computer network more frequently where the influences from computer experience background was larger than the influences from computer attitudes.

Since the subjects from the university students can be arranged and administered by the Lai' s Personality Scale, Differential Aptitude Tests and the Critical Thinking Appraisal, and their GPA can be retrieved from the university, therefore, the relationship between computer network usage and personality, aptitudes or critical thinking ability were analyzed. The findings of the Lai' s Personality Scale were that the students who were more objective, less depressed, and less nervous significantly used computer network for information searching purposes more frequently. The students who were

more social types of personality significantly used computer network for BBS purposes more frequently. The students who were more worry and distress significantly used computer network for e-mail purposes more frequently. The Differential Aptitude Tests was found that the aptitudes of arithmetic and abstract reasoning were significantly positively correlated with the frequency of computer network usage for BBS purposes. None of critical thinking abilities was significantly related to the computer network usage. The students' GPA was not found to be significantly related to the computer network usage either.

Since we sampled 110 university students for the same survey again in 2000, the changes of the computer network usage by time sequence were investigated in this research. It was found that no matter the usage of information searching, BBS, or e-mail purposes, the university students in 2000 have significantly more frequency in using computer network than the students in 1997. The university students in 2000 yielded significantly more computer experience background than did the students in 1997 too. However, for the attitudes towards computers, the university students in 2000 did not make significantly difference from the students in 1997. These results indicated that university students always respected the importance of computers in their lives. They significantly used computer network more and more by years. As a matter of fact, computer network will be the main tool to get survived in the future hi-tech world.

For surveying computer network usage of occupational groups, 115 adults were sampled in 1999. It was found that they significantly used computer network for information searching and e-mail more frequently than for BBS. No gender effect was found to be related to the usage of computer network. In addition, the more computer experience background the occupational groups have, the more significantly frequently they used computer network. However, their attitudes toward computers were not significantly related to the computer network usage. The results of age stages showed that the elder people significantly used computer network less frequently than the younger people.

General speaking, the occupational groups used computer network for e-mail purposes significantly more frequently but for BBS significantly less frequently than did the university students. The occupational groups significantly yielded more computer experiences than did the university students. It has to be mentioned here that since we sampled university students and occupational groups in different years, these results might confounded with the time effects. Further research and experimental design were suggested to verify these problems.

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Online Education: A Learner-Centered Model with Constructivism

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This paper describes the initiative to construct a WWW-enabled course and project support environment for undergraduate education, aimed to uphold the constructivist's ideas of active learning. The system is intended to create learning experiences that invite students to construct knowledge and to make meaning of their worlds of learning. In particular, we discuss the educational framework of our design through the Problem-Based Learning (PBL) approach, from the perspectives of the architect of the intellect. We also describe the incremental prototyping process of software development, through scenarios of participatory design of our students in Software Engineering at the author's affiliated faculty. The paper concludes by discussing the challenge of implementing the fully functioning constructivist WWW-based environment through blending the art and science of teaching into creative cognitive designs.

Keywords: **Constructivism, Problem-Based Learning (PBL), Learner-Centered Philosophy**

1 Introduction

With the advent of the World Wide Web (WWW or Web) towards the end of the 20th Century, the use of this Internet-based hypermedia technology in education has become the trend of today. The Web is aimed to facilitate learning in different disciplines, and is becoming the major driver to construct numerous experimental Web-based support environment in campuses around the globe. However, online education in the form of Web-based instructions (WBI) or Web-enabled learning environment, without an anchoring philosophy of education, could easily become a technology-rich educational wasteland. The theme of this paper is to investigate how the insights of our educational visionaries [5] could be designed into our Web-based support environment, to suit the unique schemata of individual learners. Actually, such designs require rigor in identifying certain essential elements of the constructivist architecture. And they represent challenges to the learning in our daily classrooms, which has typically involved having students repeat newly presented information on tests or in reports. Constructivist teaching practices help learners internalize, or transform new information, which in turn makes further understanding possible. Therefore, as instructional designers, the guiding question in tackling our Web-based design is this: How do we create a technology-enhanced learning environment that engages students in the types of activities that will take on their initiative and responsibility for their own learning?

2 Project Background

In the spring of 1999, a group of junior students in Software Engineering, initiated an informal study group (ISG) [15] with the author's facilitation. The ISG's mission is to help students develop their team-based technical interest in preparation for their graduation project. And we started exploring the ongoing development of Web-based distributed applications with online education as one of our first discussion topics. During the discussion, the author, as an instructor, expressed his difficulties in traditional classroom setting, to recognize students' intellectual and motivational problems, to explain to them a difficult part of the subject matter, to provide clear tasks, and to coach students in specific problem-solving activities. These issues indeed go far beyond the classroom walls. As students, they expressed their need for a learner-centered atmosphere whose focus is put on the needs, skills, and interests of the learners, and whose goal is

to encourage active exploration and construction in the course of learning activity. Likewise, we developed the initial idea of creating an environment where anyone is free to learn, to construct and refine new meaning in one's own learning, and to have enough channels to ask for help, when necessary, in the form of some extended service of a good teacher. We continue our expedition into Web-based technology to turn out the project ideas of creating a) a course support environment for active learning, and b) a project support environment for problem-based learning (PBL). The former has been given the project name **REAL** [13] to imply a Rich Environment for Active Learning, while the latter, **SUPER** [14] to denote SUitable and Practical Educational Resources for group-based project work. And in either project, we have not ruled out the familiar face-to-face classroom interactions between teacher and students, as one of the essential aspects of the learning process.

3 Pedagogical Intakes

In selecting the pedagogy of our Web-based environment, we have borrowed from the legacies of our educational visionaries in blending the art and science of constructivist teaching. John Dewey's designs embedded learning in experience [3]. He advocated field studies and immersion in experiences to stimulate learning. Jean Piaget's work influences constructivist educators through designs of discovery learning [9]. Students manipulate subject matter and objects representing the subject matter as they interpret their findings. He believed that learners' internalization leads to structural changes in how they think about something as they assimilate incoming data. Today, constructing meaning on the basis of one's interpretation of data is the heart of science inquiry, problem-based learning models, and case studies. Lev Vygotsky's theory [16] suggests that we learn first through person-to-person interactions and then individually through an internalization process that leads to deep understanding. This belief in the social process of idea making permeates today's interactive classroom led by skillful teacher questioning. Reuven Feuerstein's mediated learning theory [4] refutes the concept of an unchanging intelligent quotient (IQ) and leads to intense examination of how the classroom affects students' metacognition. He believes that the discovery process requires intervention from the teacher to guide learning. On examining the varied work of the master architects, and trying to crystallize the essential elements of the constructivist architecture, we see an array of tools emerging. They include a learner-centered curriculum; enriched environments; interactive settings; differentiated instruction; inquiry, experimentation, and investigation; mediation and facilitation; and metacognitive reflection.

4 Instructional Design

We expect the instructional design of our Web-based support should increase student participation and communication through re-designing the delivery of college lectures to incorporate more student online activities and instructor's feedback before, during and after the contact session. The environment is expected to develop students' abilities to generate problems, to engage in collaboration, to appreciate multiple perspectives, to evaluate and to actively use knowledge. From the designers' standpoint, we have included the following enabling ideas:

a) *Enable students to determine what they need to learn through questioning and goal setting.* It is believed that students should work to identify their knowledge and skill deficits, and to develop strategies in the form of personal learning goals for meeting those deficits. The emphasis is to foster a sense of students' ownership in the learning process. If teachers, through the Web-based support environment, can guide the students in identifying what they already know and what they need to learn, then knowledge gaps and mistakes can be viewed in a positive way such as another opportunity to learn. And students can assume more responsibility in addressing their own learning needs during any instructional unit.

b) *Enable students to manage their own learning activities.* It is believed that students should be enabled to develop their learning plans, which should describe priorities, instructional tactics, resources, deadlines, roles in collaborative learning situations, and proposed learning outcomes, including presentation and dissemination of new knowledge and skills, if applicable. Traditionally, these instructional events are arranged by teachers to be obeyed by students, in order to accomplish a specified set of pre-determined objectives. Yet, it is not advantageous for students to learn to be self-directed. To manage their own learning activities, students must be guided and supported by the teacher, through the Web-based environment, slowly taking on more and more responsibility of their own learning.

c) Enable students to contribute to one another's learning through collaborative activities. It is believed that

students should be encouraged and supported to discuss and share their personal findings. Particularly, we should enable students to become co-builders of the course/learning resources through evaluating and refining the entries their peers put into the Web-based depository. Collaborative group-based learning seems appealing to achieve the purpose. Students, nevertheless, must be educated to recognize what they are trying to learn in group-work, value it, and wish to share that value with others. Teachers can provide this sense of accountability and belonging by structuring students' work in the support environment with such concept as computer-supported cooperative work (CSCW).

It is convinced that the efficacy of the learning environment is a function of many complex factors, including curriculum, instructional methodology, student motivation, and students' developmental readiness. Trying to capture this complexity onto the design of our Web-based environment, is more an ongoing iterative process than a one-time activity. So we develop scenarios of situated learning support applicable to both individual course taking and group-based project work. These scenario-based supports are then incorporated into the environment incrementally, subject to our students' participatory testing.

5 Scenario-Based Support

Imagine attending a class where the instructor, after giving an introduction of what the course is entailed, invites you to visit his/her course support environment on the Web. On entering the Web-based environment, you are offered the privilege of creating your own personal space in the form of a customizable Web page guarded by your self-assigned identifier and password. Within your personal Web space, you are furnished with some tools to start your Web-life. These include a communications facility to keep one another in touch (email and newsgroup); a calendar planner to track your appointments or commitments (meetings or homework due dates, or project deadlines); and a frequently-asked-questions (FAQ) tool to send for instructor's help when encountering difficulty in housekeeping the personal space. Also, there are pathways to other service modules:

a) Course Information. This module provides such information as the course description, pre-requisite requirements, evaluation policy, references list, and other details such as time and location of the lectures. It also includes links to the instructor's contact details, his/her teaching/research profile, and the course schedule showing timetable for class with links to the study materials before, during and after contact sessions. Also included is the announcement service representing the most up-to-date information sent to the students from the instructor.

b) Course Resources. This module comprises the study materials prepared by the instructors, and the contributions representing students' submitted or reported work of interest to other students. Study materials can further be cataloged and managed as different resources: study notes, tutorial handouts, supplementary lecture details, or Web-links in the Internet. It could also include FAQs of the course: homework, quiz's, tests, examinations, and projects.

c) Course Assessment. This module keeps track of students' performance. The score each student obtained after completing a specific activity is recorded with enough details for evaluation at the end of the course. Students are encouraged to propose their own study plan to earn the accumulated score required, to complete the course. This service is designed into the Learning Contract [7] component to individualize the learning process for any individual learner. Typically, a student is required to write a formal agreement, which details what will be learned, how the learning will be accomplished, the period of time involved, and the specific evaluation criteria to be used in judging the completion of the learning.

d) Course Inquiry. This module fulfills several requirements of the teacher-student inquiry interaction. These include: a) a sense of dedicated space for an extended collaboration between teacher and student; b) an incremental delivery of inquiry results from teacher to student; and c) visibility of the inquiry interactions to avoid duplicating effort, and to encourage discovery of related interests. When an inquiry is initiated by a student, a request Web page is generated which is specific to that interaction and to which the teacher and student return frequently for their interaction. This request Web page (meeting space on the Web), contains the relevant material required for the specific inquiry interaction, say, contact details of the student and the teacher in the form of Web links or email addresses. Each request Web page supports several types of interaction: posting comments, recording actions, uploading/downloading files. These can be carried out at any time in any order. This feature is designed to support the often-time extended discussion and incremental result delivery of the teacher-student collaboration. Also, since the completed

request Web page could be visible to any registered student or teaching staff within the Faculty intranet, this increases the general awareness of the teacher's activities in consulting students, and avoids duplicating efforts of other staff in dealing with similar questions from students. More importantly, when users browse the inquiry activities over the Web, they are always exposed to information as to who was involved in what, and eventually they will learn about one another's specialties and interests. Hopefully, they will form communities centered about specific knowledge and interest; such are considered as important assets of any educational institute.

Now, on visiting the Web-based support environment and reading the latest announcement for the next lesson, you are aware that the next lesson is about group-based project work. According to the instructor's message, group project work is an essential component of any academic degree; many professional societies worldwide emphasize project and group work as preparation for professional practice. Also, you are to follow the problem-based learning (PBL) approach to work in teams. And you will be introduced to the teaming process and the PBL support of the Web-based environment.

6 Problem-Based Learning (PBL)

It is understood that project work is recognized as having many educational and social benefits, in particular providing students with opportunities for active learning. However, teaching, directing and managing group project work is not an easy process. This is because projects are often: *expensive* demanding considerable supervision and technical resources; and *complex* combining design, human communication, human-computer interaction, and technology to satisfy objectives ranging from consolidation of technical skills through provoking insight into organizational practice, teamwork and professional issues, to inculcating academic discipline and presentation skills. In preparing our students to get started with group-based project work, we have oriented towards the PBL learning model. According to the literature [1, 2], the modern history of PBL began in the early 1970s at the medical school at McMaster University in Canada, and ever since, PBL has been adopted in various fields such as Teaching, Engineering and Management.

6.1 PBL Pedagogy

The PBL approach focuses education around a set of realistic, intrinsically motivating problems to fit the interests and needs of the learners. It acknowledges the possibility of prior knowledge held by the learner. Further knowledge is acquired on a 'need to know' basis, enabling the learner to diagnose one's own learning needs. Knowledge gained is fed back into the problem in an iterative loop, allowing the synthesis of topics and know-how [10]. When applied to the course setting, PBL should encourage students' active participation, and develop in them self-directed learning and problem-solving skills while they interact, discuss and share relevant knowledge and experience. More importantly, PBL revolves around a focal problem, group work, feedback, class discussion, skill development and final reporting. The instructor's role is to organize and pilot this cycle of activity, guiding, probing and supporting students' initiatives along the way so as to empower them to be responsible in their own learning.

6.2 PBL Activities

Students, on being presented with a problem or scenario, are made aware that initially they will not possess enough prior information to solve the problem at hand or to clarify the scenario immediately. These problems are often ill-structured, but devised according to concrete, open-ended situations. They are reminded that they must identify, locate, and use appropriate resources, and ask questions referred to as "learning issues" on the various aspects of the problem. These learning issues should help them realize what knowledge they require to construct a solution, and thus focus their learning efforts and establish a means for integrating the information they acquire. Often, they are encouraged to perceive themselves as managers of their own in terms of time, material resources, and the complexity of the problems that can be handled one at a time by the group. It is expected that the PBL students have to iterate through some relevant stages of activities: analysis, research, and reporting, with discussion and feedback from peers and the instructor at each stage.

• *Analysis.* Throughout this stage, students organize their ideas and prior knowledge related to the problem, and start defining its requirements. This helps them devise a specific statement of the problem. Meanwhile, they are encouraged to pose learning issues, defining what they know and what they do not know. This helps them assign responsibilities for research, eliciting and activating their existing knowledge as a crucial step in

learning new information.

• *Research.* Throughout this stage, students collect necessary information on specific learning issues raised by the group. They may conduct library searches, seek sources on the Internet, collect data, and interview knowledgeable authorities. More importantly, students teach themselves as they research their learning issues. It is intended that when they come to realize the complexity and texture of the problem, they may often see that information is a means to the ends of managing problems effectively.

• *Reporting.* At this stage, students report their findings to the group. Individual students become "experts" and teach one another. Subsequently, their discussion may generate a possible solution, or new learning issues for the group to explore further. Final solutions are constructed, and the facilitator's feedback should help students clarify basic information, focus their investigations, and refine their problem-solving strategies, besides addressing whether the original learning issues were resolved and whether the students' understanding of the basic principles, information, and relationships is sufficiently deep and accurate.

6.3 PBL Teamwork Experience

It is important that PBL students are taught how to work in teams and positively experience the team process because the team skills they acquire are applicable throughout their future careers. The PBL team process requires each team composed of 3-5 students, to be assigned a supervisor (instructor) and a client if applicable. The client's role is to clarify the project, and to resolve ambiguities as they arise, whereas the supervisor's is to guide, motivate and provide feedback to the team. Also, one of the team members is designated the team leader for the duration of the project, whose role is to coordinate the team activities, and to ensure effective team communications. The leader also has to interface with the supervisor, arrange meetings with clients when necessary, and facilitate meeting through setting agendas, taking minutes, and allocating tasks. Each team member has to help set the team goals, accomplish tasks assigned, meet deadlines, attend team meetings and take a turn editing a document to be submitted at the end of each major stage of project development.

Meanwhile, PBL students are made aware of the difficulties in teamwork throughout the project period. These include setting realistic project goals, carefully allocating tasks to team members, managing time, and communicating and managing shared group documents. Teams have regular meetings to which they invite their supervisor, and in which they organize themselves to manage the project. Students are often reminded of setting appropriate agendas before meeting, assigning enough time to the agenda items during meeting, restating the decisions made at the meeting, and converting decisions into action items after meeting. They are also advised on clearly separating the social and work aspects in meetings, and assessing each meeting for doing it better next time. Moreover, it is suggested that teams plan their project around major deadlines of individuals in the team thereby acknowledging the other commitments team members may involve.

Deadlines represent the milestones set down for the PBL students to submit project documents and to receive evaluation. Each team member is assessed by their supervisor and their team peers. The supervisor's evaluation is based on what each team member adds to the meetings and what the instructor perceives each member's contributions to the team to be. The peers' evaluation is based on a confidential rating sheet, to be completed by each team member at the end of each major phase of the project. This rating sheet should include each team member's contribution for that phase with explanatory comments. And the overall project assessment is made up of the group grade and the individual grade. The former is the same for each group member and is based on the quality of the documents produced and the product developed. The individual component is based on the quality of the student's contribution to the documents and the product, their participation in group-meetings, their commitment to the team process, and their professional attitude developed.

7 Scenario-Based PBL Support

Imagine you have just attended the second lesson on PBL and group project work. And you realize that the PBL support available in the Web comprises both the learning and performance aspects. These are actually a series of strategies and Web-based solutions that use instructional design principles to improve students' work-based performance according to the real-life PBL activities. And you are invited to visit the PBL-specific Web site to register as a PBL-user. The registration process invites you to fill in a Web form including a simple questionnaire for teaming purpose. You are now allowed to enter the PBL-support environment with your PBL identifier and personal password returned after the registration.

And for exploratory purpose, you have just navigated to the PBL Web page for the Software Engineering course *SFTW 300 Software Psychology* (Figure 1). Here you are presented with a number of projects to express your preferences to join through filling in another Web form activated by clicking the link "Join a Team" in the same page. You can then find out which team and project have actually been associated with you by clicking the link "Identify Your Team" also in the same page. On knowing which project to engage, you could click the suitable PBL Space link, i.e., "S300F99P3" in this case, to navigate to the suitable PBL Space (Figure 2). The PBL Space is assigned for each PBL group for project management on the Web. It contains links to the project itself, the PBL Group (including its members' links), the PBL Client, and the PBL Supervisor. Each of such links is associated with a set of related links for information and support of the project. Among the numerous support links in the PBL Group, you can find the *Work Space* link, which leads to the "Group Work Space" (Figure 3) Web page. This page contains links to individual group members and to specific PBL support, as well as to the project interim progress. Clicking on the individual member's link (PWS) leads to the "Personal Work Space" (Figure 4), where each group member's progress in terms of PBL activities (analysis, research, reporting, implementation) is tracked.

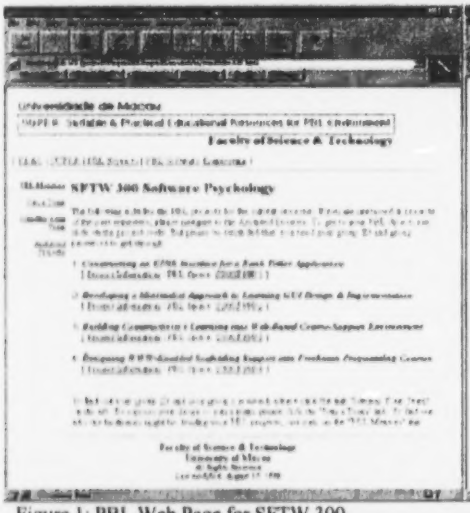

Figure 1: PBL Web Page for SFTW 300

Figure 2: PBL Space for SFTW 300 Project

Figure 3: Group Work Space for a SFTW 300 Project

Figure 4: Personal Work Space for a SFTW 300 Project

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8 Software Development

Our database-driven Web-based support environment has been developed as a series of distributed applications, by employing a mixture of object-orientation, client/server, and Internet (Web browsers, Web servers – HTML, HTTP, FTP) technologies, to deliver the desired support functionality. Such applications are largely event-driven because of the intensive graphical user interface (GUI) programming (e.g., handling the points and clicks) and/or because of the message exchanged between clients and servers over the Web. The specific types of individual Web applications constructed can be categorized into such classes as: a) static HTML-based, b) server-side (CGI-based) and c) client-side (Java-based or JavaScript-based). And the major steps followed to develop the distributed applications could be abstracted as follows:

a) Analysis. Establish users' requirements of what information are needed by whom and when, in terms of functionality, performance, security, operability, and management of the distributed applications. And develop an object model that shows conceptually how the information will be organized, accessed, manipulated, and presented in terms of objects.

b) Architecture. Partition the architecture concerns into: *data architecture*, determining what data sources (HTML, files, databases) will be needed, where they will be located, and how they will be accessed; *software architecture*, determining what will be written as CGI/Java code, what will be constructed as modules called by CGI/Java, where will the various objects/modules reside, and how they will be invoked (CORBA, RPC); *infrastructure architecture*, determining the servers where the home pages and the objects/modules will reside, the type of gateways that will be employed, the type of middleware that will be needed to invoke remote services and objects (CORBA, ActiveX, RPC, SQL), and the type of computing platforms (PC Windows, UNIX, Linux, Windows NT) used.

c) Implementation and Deployment. Build the HTML pages (including the Java-powered pages) by coding HTML or using filters that generate HTML from other data sources (e.g. Word documents). Then develop and test the software modules and objects. If necessary, purchase the appropriate infrastructure components. Fourth, test, install and deploy the system, followed by maintenance and the iterative re-design process.

9 Prototyping Process

The Web-based support in our online environment is developed incrementally through a user-driven iterative prototyping process, which involves our instructional designers, teachers, and students in the participatory development. This involves creating a series of function prototypes used to clarify the objectives of the system in light of design exploration between the designer and the users (teachers and students), so that the users gradually understand what can be achieved with the technology. Our knowledge of requirements, design and implementation may be incomplete in any one cycle; however, there has been progressive build-up of a structure, which will lead to the desirable system. Specifically, we have referred to the Dynamic Systems Development Method (DSDM) [12] for project guidance, which walks us through four main phases of the DSDM life cycle.

The *feasibility study* phase is to define the high level functional requirements of the environment, which refer to the educational support issues. This phase should produce an outline prototyping plan and establish the main non-functional requirements, such as the hardware and software to develop and deliver the system. The *functional prototype iterations* phase is to clarify the detailed requirements for the system. Its output includes a series of prototypes that demonstrate the main system functionality. These early visual prototypes are mainly used to clarify the system objectives between the designers and users. The *design prototype iterations* phase is to refine the functional prototype into a robust product after a more situated evaluation of system requirements. It involves satisfying all the non-functional requirements; i.e., producing a system that will work effectively on the target hardware in the organizational setting. It is understood that all the possible components of the system do not have to be developed in unison. Some may move on to the design and build phase while others are still at the functional clarification stage. The *implementation* phase involves placing the system in the user environment, carrying out any required training, reviewing the system and assessing further developments. The output should include a delivered system, user manuals/training, and project review document.

10 Conclusion

It is experienced that the conventional approach to education remains the instructivist one, in which knowledge is perceived to flow from experts to novices. This transmissive view of learning is most evident in the emphasis on lectures, in the use of textbooks to prescribe reading, and in the nature of tutorials and assessment methods. It assumes that the process of good teaching is one of simplification of the truth in order to reduce student confusion. Yet, this simplification could deny students the opportunity to apply their learning to dynamic situations. We question the transferability of the instructivist learning and ask how much of that which is assigned to academic learning ever gets applied to actual scenarios, when there is such a rapid surge in knowledge commonly associated with the birth of the "Information Age." This is a transference problem. Actually, the content product of learning is assuming a less important role relative to the process of learning as the life of information content shortens and the need for continual learning increases. In designing the Web-based support of our learner-centered environment, we have tried to reoriented towards a meaningful direction by reducing the obsession with knowledge reproduction. And PBL represents one such relief from the constructivist pedagogy. Greening [6] describes it as a vehicle for encouraging student ownership of the learning environment. There is an emphasis on contextualization of the learning scenario, providing a basis for later transference, and learning is accompanied by reflection as an important meta-cognitive exercise. Also, the implementation of PBL is done via group-based work, reflecting the constructivist focus on the value of negotiated meaning. Besides, it is unconfined by discipline boundaries, encouraging an integrative approach to learning, which is based on requirements of the problem as perceived by the learners themselves.

Undeniably, constructivism is a philosophy of learning that is having a major effect on the way that education is conducted today. In this paper, we have tried to spell out the working characteristics of constructivism [11], which have actively shaped the design of our Web-based support. These include: 1) Meaning is not transmitted. Instead, learning occurs as a process of adjustment of existing concepts. 2) Understanding is based on interaction among a complex weave of factors, such as the learners' goals and existing concepts, the content of the learning experience, the context where the learning occurs. 3) Puzzlement motivates learning. This sense of dissatisfaction emerges from experiences that threaten existing conceptual structures. 4) Social negotiation and viability are the principle forces involved in the evolution of knowledge. They ensure that learning is anchored both by the learning community and by the need to test constructions against reality. The effects of such testing are the adjustments in the structure of concepts held by the learner. So, one thing is evident: constructivist learning experiences can exert high cognitive demands on learners [8], and not all learners could respond well to the challenge. We believe the constructivist ideas assembled here make up what we might call pragmatic constructivism. Namely, constructivism could be viewed as a toolbox for problems of learning. If a particular approach does not solve the problem, try another. In keeping with this flexibility, active, social and creative learning can play out in rather different ways, depending on the circumstances. Although the term constructivism suggests a single philosophy and a unique potent method, there is not such thing as a one-size-fit-all. Rather, our suggestion is to look at constructivism like a Swiss knife with various blades for various needs. That is also the learner-centered philosophy behind our Web-based support for online education.

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Peer Help for Problem-Based Learning

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This paper describes the I-Help peer help network, where helpers and helpees are paired according to the contents of their user models. Although originally designed for large groups, in this paper we suggest ways in which I-Help may be used in a small group, problem-based learning curriculum. The use of I-Help will be very different in this context: it is not expected to be necessary for all students. However, some learners may experience difficulties with some aspects of problem-based learning, such as: scheduling of meetings; involvement in discussions; understanding roles; acquiring skills for problem-based learning; different interaction preferences; differences in cognitive styles. We describe how I-Help may be used to alleviate some of these difficulties, in particular: by putting groups into contact with other groups; or putting individuals into contact with someone outside their group who can advise, or who is facing similar problems, and would like to explore the issues jointly. At the same time, group cohesion is not disrupted.

Keywords: **peer help, problem-based learning, student modelling.**

1 Introduction

Problem-based learning (PBL) is used in many academic subjects (e.g. architecture, business, education, engineering, law, medicine). The first implementations were in medical education, and PBL is still used in many medical sciences courses today. We therefore focus on medical education in this paper, though many of the arguments are applicable to a range of subjects.

Medicine is a difficult subject to teach and learn: the knowledge to be acquired and integrated is broad and very complex. This knowledge is useful only if it can be applied to problems presented by real patients. Such problems are ill-structured, specified with partial information, and often complicated by diverse interacting factors. While acquiring basic domain knowledge is a fundamental activity in medical education, integrative problem-solving is also a fundamental goal.

PBL attempts to focus learning around authentic patient problems or cases, which bring together many interacting issues of a multidisciplinary nature. A core aspect of PBL is that problems should be only partially specified. PBL involves the student in a practical activity, carried out in small groups (usually 4-8, facilitated by a tutor) in which students identify and research their own learning issues [17]. Typically a group will meet to discuss a case, identify learning issues, and then research these individually using a variety of resources (e.g. print-based, web-based and people). They then meet again to report and discuss the case further.

Investigations into the benefits of PBL have produced mixed results, possibly in part because traditional assessment mechanisms are less appropriate measures of the goals of PBL [13,30]. It is stressed that there is, as yet, no evidence that a PBL curriculum is more successful than a traditional approach [27]. Nevertheless, PBL has been embraced by some as the preferred approach to medical education, advantages cited including: the self-directed nature of PBL [27]; a greater tendency towards a deep approach to learning [21]; and positive student attitudes [6]. Others suggest that acquisition of basic domain knowledge may not be well supported in PBL. Learners may later recall less factual knowledge, since they are spending time learning other skills in addition to content [30], and they may lack depth of knowledge [18]. Explanations generated by PBL students can be less coherent, and more frequently incorrect [23]. Learners may also become bored with the PBL process [29]. It has also been recognised that PBL may simply not suit all students' ways of learning [10]. While the peer help system described in this paper can assist in a number of areas, it is this latter aspect that we focus on here.

This paper is neither a critique nor an endorsement of PBL. However, we emphasise that in PBL (as in traditional education), there is a need for tools to support peer interaction for situations where learners need assistance. In this paper we describe how the I-Help (Intelligent Help) system can be used to support students who have difficulties with the PBL approach by putting groups into contact with other groups, or an individual into contact with another learner who may advise or collaborate.

Section 2 of this paper introduces existing examples of computer support for PBL, and describes other systems which mediate peer help. The advantages of I-Help in large groups are described in Section 3. Section 4 discusses how the large group implementation of I-Help may be adapted to support PBL students when they are experiencing problems with the PBL approach. Conclusions are presented in Section 5.

2 Computer support for problem-based learning and peer help

Computer support for group interaction in PBL has been implemented for the asynchronous distance education context; the synchronous distributed learning context; and the co-present small group situation. Kamin et al. [15] describe a combined Web/CD-ROM program containing a video patient case, for use by a group of third year medical students and tutor. It is designed to facilitate asynchronous PBL during a clinical course component, requiring independent and collaborative involvement. Cameron et al. [5] discuss a distributed problem-based learning project using conferencing software together with a web page, to support synchronous sessions aimed at enabling 'authentic PBL' to occur amongst distributed first/second year medical students and a tutor. Koschmann et al. [16] introduce a method of conducting PBL meetings between students and tutor in a face-to-face context, using connected individual laptops and a large shared display. This approach is close to that found in PBL meetings not supported by computers, but offers some advantages: parallel polling (to ascertain each group member's views before they hear the ideas of others); and a record of contributions.

Computer support for PBL may, or may not include actual cases within the program: students may be collaborating about computer-presented cases, or interacting through the computer environment about externally introduced cases. External cases may be provided by the tutor off-line, or may be drawn from a database of patient cases (e.g. PATSy [19]). Systems to support PBL may help to structure and focus PBL discussions. However, even where such systems are available to a student, we believe that additional support is needed by some learners, to help them cope with the PBL situation if they feel uncomfortable with some aspects of it.

While it is acknowledged that many learners benefit from collaborative work, it is also the case that collaboration will not suit all learners; or a particular instantiation of a computational or non-computational collaborative learning environment may not suit a learner who could potentially gain much from collaborative interaction. Thus more flexible means of facilitating peer interaction would be useful. This kind of support will differ from that provided by systems such as the above: students who find the PBL approach difficult may find it useful to be put into contact with a peer who can share experiences about specific aspects of PBL.

An increasing number of peer help systems are attempting to organise learner interactions according to the student models of the individuals concerned – i.e. they have a matchmaking component; or by learner selection of available helpers. The matchmakers in such systems can take account of a variety of factors, but they most often look at students' relative proficiencies in the target domain. A few examples are given below.

An example of a peer help environment is that of Yu et al. [31], where more advanced learners act as mentors. Mentors are selected according to their knowledge, with reference to the following criteria: students who have successfully completed the course; students with high grades in other courses; students who have finished assignments; students who have successfully completed the computer-based tasks about which others need help; teachers and teaching assistants. The assumption is that the group of mentors and the student group do not overlap (though Yu et al. suggest extending the system to allow student-student help). Students select mentors based on availability (mentors may be involved in up to three help sessions); and the current problem (mentors may only help on one problem area at a time).

The above example has the advantage that learners choose to receive help when they need it, and are not forced into a collaborative context if they prefer not to participate. Further, they are guaranteed a knowledgeable helper. Nevertheless, there are drawbacks to this approach outside the setting for which it was designed. The set-up is very rigid: currently only externally acceptable (i.e. tutor-selected) individuals may be mentors. This does ensure that helpers are knowledgeable, but it does not require that they are good helpers. It also does not take account of the fact that students may benefit educationally from giving help, as well as receiving it.

Hoppe [14] proposes integrating knowledge from individual student models to support group learning – i.e. to parameterize group learning. One of the benefits is that peer helpers may be selected for help sessions: a knowledgeable helper can be partnered with a less knowledgeable student. In Hoppe's work this occurs as follows: a learner issues a help request; a menu of potential suitable helpers is offered; the learner selects their choice of helper; the selected helper receives the help request; the helper accepts or rejects the request. This approach is claimed to avoid personal conflicts, as helpers are neither assigned, nor must they interact directly with the helpee if they wish to refuse. It also allows all participants the opportunity to be helpers, as long as they know about the topic. It does not guarantee, however, that selected helpers will be proficient at helping.

Ogata et al. [22] extend this notion of peer help networks, taking into account pre-existing social networks amongst individuals, claiming that these are at least as consequential in a help context, as more official organisational structures. Ogata et al.'s approach allows users to register their proficiencies and social networks, and it also automatically traces user relationships by logging email exchanges. This provides additional information on personal networks, and also on abilities of the user: if an individual answers a question posed by a peer, the helper is assumed to be knowledgeable. These relationships are taken into account when matching potential helpers with those requesting help.

The above approaches allow peer interactions to be initiated by a learner, as required. Helpers are contacted, and may choose to take up or reject interactions. The first example [31] does not require extensive student models, but is quite restricted. The second example [14] expects student models to be in place, though overlay models are sufficient to indicate knowledge levels of individuals. The final example [22] does not require detailed models of knowledge, since it relies on social closeness and self-evaluations together with assumptions about competence based on question keywords in a help request, that has been responded to by the individual being modelled. However, what is not present in these approaches is an ability to match students according to their preferences of interaction method, or individual cognitive style, or to take into account a helper's ability to *help*. Such issues may be just as important for peer interaction to be successful.

The following section describes I-Help: an environment based on multiple user models, to match students who have help requests with potential peer helpers. I-Help aims to accommodate a broader range of characteristics that might be important when pairing learners. Suggestions of how I-Help might be usefully applied in PBL are then given in Section 4. This includes the more common face-to-face PBL context, and use alongside software to support group interaction in PBL, such as described at the beginning of this section.

3 I-Help

I-Help is the integration of several information/help sources brought together through the metaphor of a help-desk [12], designed originally for large student groups. The two principal components are an asynchronous public discussion forum [3], and a one-on-one private discussion facility which may be used synchronously or asynchronously. In the case of the private discussions, multiple distributed user models are used [20] to match students who can help each other in their learning. Each user has a personal agent which uses its owner's student model as a source of information for negotiating help sessions with other users, through their respective personal agents [28]. (Some examples of agent personas are shown in Figure 1.) The following illustrates the sequence of events for a help request. (For an example see [11]).

1. A student contacts their agent to issue a request for peer help;
2. The student's agent negotiates with the agents of other learners, to find appropriate helpers;
3. The top five user-matches are emailed that there is a help request waiting for them in I-Help;
4. To ensure maximum immediacy of response, while not duplicating effort, the first helper to accept the request starts a one-on-one discussion. Requests to other potential helpers are thereby cancelled;
5. Upon completion of discussion, each learner receives an evaluation form through which they evaluate their partner, for student modelling purposes.

The I-Help student model is composed, as stated above, in part from peer evaluations given at the end of a help session by both helper and helpee, about the knowledge of the other participant. The student model also comprises self-evaluations of knowledge level in each of the domain areas. In addition, helpees rate the utility of the help received. Social issues are also considered: learners can add users to their 'friends' list–i.e. people with whom they will preferentially interact, be they 'real friends' or people they do not know, but who have been helpful to them in the past. Students may also add individuals to their 'banned' list–people with whom they wish to have no further dealings. Much information for the student model is easily captured, since it is user-given. It is continually updated as peers evaluate help sessions once they are completed.

Also modelled are individuals' cognitive styles. The identification of cognitive style is based on Riding and Cheema's classification [26], which comprises two dimensions: wholist-analytic and verbal-imagery. The wholist-analytic dimension refers to the extent to which an individual usually *processes* information in *wholes* or separate *parts*; the verbal-imagery style relates to the degree to which an individual tends to *represent* information during thinking in a *verbal* or *image* form. In I-Help this information is provided through a front-end questionnaire. The questionnaire is very short, designed for students who may not themselves be interested in the outcome. The aim is to encourage learners to provide at least some information. While recognising that this is not ideal, partial cognitive style information is considered preferable to no information at all.

Five question types were identified, requiring different cognitive style combinations of helper and helpee:

1. *How does this fit with other things?*
   The first choice of helper for this type of question is a wholist, regardless of the cognitive style of the helpee, because wholists will tend to be better equipped to provide a broader overview.
2. *What are the details of...?*
   For this question type an analytic helper is preferred, regardless of whether this matches with the cognitive style of the helpee, because analytics tend to grasp the details of a topic more readily than wholists.
3. *Can you recommend any good materials for...?*
   The aim is to match individuals on the verbal-imagery dimension, since a verbal learner will more likely recommend materials helpful to another verbaliser, and an imager will do likewise for another imager.
4. *Miscellaneous question*
   This category covers any questions not included in the above. The default is to match all learners on the wholist-analytic dimension. If possible, learners are also matched on the verbal-imagery dimension.
5. *Questions requiring simple answers*
   No cognitive style matching is undertaken for straightforward questions requiring a simple answer, as cognitive styles are likely to have little impact here.

When submitting a help request, the learner indicates the question type from the above selection.

In addition to self and peer user-given information, learner models are updated automatically based on observations of eagerness (browsing and active posting behaviour in the public discussion forums, and amount of help given in private discussions). Furthermore, personal agents note which cognitive style matches seem most successful for different question types, and update the user model accordingly. (This also helps to overcome potential inaccuracies in the initial self-report.) Figure 1 illustrates the sources of information for the student model (open arrowheads), and the differences between private and public discussions. In the private discussions a learner interacts directly with a single peer in each dialogue, to give and receive help. Public discussions take place in forums – there is no direct interaction between two people (solid arrowheads).

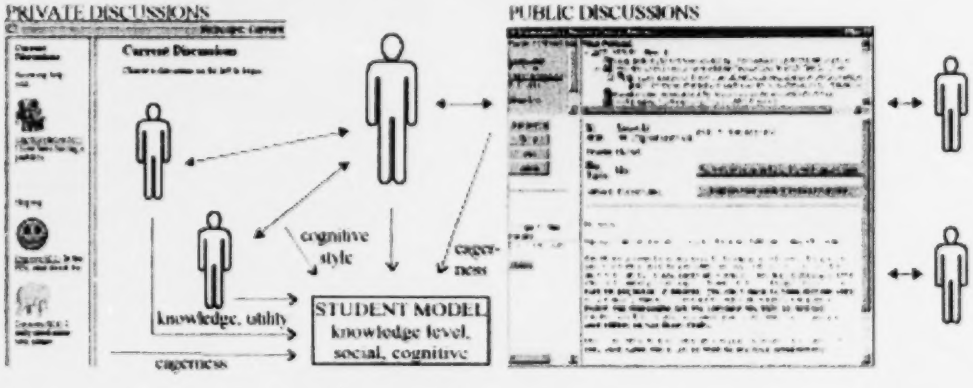

Figure 1: I-Help public and private discussions

In seeking partners, a personal agent tries to balance all relevant information (k owledge level of helpers; helpfulness of helpers; eagerness to help; preferential friends; exclusion of banned people; appropriateness of cognitive style). By default these issues are given equal weighting, but the learner may re-rank each component, as is important for them. For example, some learners may have more flexible cognitive styles. For such students, style may be a relatively unimportant factor. Other students will have more difficulty adapting to someone else's way of learning, and will assign greater importance to cognitive styles – perhaps even preferring this kind of match above the requirement that a helper should be very knowledgeable.

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A variation on the peer help scenario involves permitting students to choose the kind of interaction they want, based on the S/UM system [4]. In addition to peer help, students may seek: peer feedback about work drafted or completed; collaborative learning; cooperative learning (i.e. X learns A & Y learns B, followed by tutoring or reporting). In addition to peer help, this allows students who wish to learn collaboratively or cooperatively the opportunity to find the most suitable partner. When a user sends an interaction request, they specify the kind of interaction they are seeking. Their agent negotiates a match with someone who also wishes to interact in that manner, and who has appropriate characteristics (e.g. a helper should have greater proficiency in the topic than the helpee; a collaborative partner should have a similar, non-expert, knowledge level).

In summary, the utility of I-Help increases with the number of users, as good matches become more feasible. Much of the user modelling is performed quickly and naturally by users (self- and peer-evaluations), and these models by themselves are sufficient even early during interactions, before additional system modelling has occurred. Student models contain content, cognitive and social information, which can be ranked in order of importance by learners. Further, I-Help can easily be applied across a broad set of courses: all that is required is a course description (in the form of course component labels) to be provided by the course tutor. Knowledge levels represented in user models, to contribute to matchmaking, are then related to these labels. Apart from reducing the load on tutors, from students requesting information, there are three major educational benefits:

- Students receive help when they have difficulties;
- Students learn through encountering the possibly conflicting viewpoints of others;
- Students will necessarily reflect on an issue when giving help on it.

Thus it is not only those receiving help, who benefit.

4 I-Help in problem-based learning

Due to the nature of PBL, students undertake a lot more research than traditionally educated learners, relying less on teacher-recommended texts. Many students use electronic resources more heavily than other resources [8], and they also use general library resources more extensively than their traditional counterparts [2]. I-Help provides additional human resources, forming a natural extension of this situation, and is likely to be useful to many students in PBL during the research phase. However, in this paper we focus on supporting those students who are uncomfortable with some aspects of the PBL approach itself.

Since PBL is focussed around small pre-established peer groups it is less obvious how I-Help might be applied, as opposed to in larger, traditional classes for which it was originally designed. Nevertheless, as illustrated in the following description, there are a number of situations in which I-Help could be useful in PBL.

There are a variety of potential difficulties to take into account in a PBL course. For example:

- It can be difficult for some students to find time to meet outside scheduled class hours;
- For a group to function effectively, individual team members should all be involved in group discussions;
- Students may not fully understand their role in the group;
- Students may lack the skills to make group interactions work;
- Students have different interaction preferences;
- Students have different cognitive styles.

Considering the first two of these issues, the public discussion forum of I-Help is a useful tool to keep all students in contact with their own group's discussions, but also allowing interaction between particular group members, should help or clarification be needed by some participants, on some group issue. At the same time, all students remain up-to-date with all interactions, at a time that suits them, thus freeing up part of meeting times for questions and group issues less easily handled through computer interaction.

Perhaps more unusual in the PBL context: there may be occasions when students could usefully interact *across* groups. As suggested above, it is not the aim to exclude any group members from any interaction important for group progress, but there may be situations where individuals from different groups could help each other, on issues perceived as not directly relevant to either group as a whole. For example, in some PBL contexts the various roles are divided amongst group members, often rotating. In such situations it might be helpful if individuals from different groups who are performing the same role (e.g. scribe; group leader; information analyst), could interact – especially if it is early in the rotation, and there is less group experience on which to draw. It will also be helpful for students finding their role difficult, who are part of a group whose members do not appreciate the learner's problems. Their personal agent could locate a helper who has successfully fulfilled the responsibilities of the role in the past, or find another student with similar problems, with whom they can

jointly explore aspects of the role. Where the whole group acknowledges a lack of understanding of any role, one of the group members may seek outside assistance on behalf of everyone.

I-Help's user models must therefore be extended to include information about student roles. I-Help must know the current role of individuals, in order to put students in touch with others facing the same tasks; and it should also remember the roles that individuals have previously held, and whether they were competent, and whether they are willing to offer help to novices in these roles. I-Help may then be used to pair individuals in interactions relating to role responsibilities, keeping such interactions amongst those for whom the discussion is currently relevant and/or helpful. As more students come to perform each role, previous help session archives may be accessed as help resources. In this manner, it is hoped that more students may develop an understanding of how to meet their various responsibilities, resulting in improved group functioning.

It has been commonly noted that many students entering the medical sciences do not possess the skills necessary for effective group interaction in PBL – e.g. discussion, decision making, conflict management, leadership, group feedback processes [24]. Although I-Help does not teach these skills, its ability to match students with others who are in a similar position, or who are able to help, provides a form of support not usually available. If a single individual has problems, the other group members may be able to compensate while also supporting the learner's development of the skill concerned. However, where group members recognise a general deficiency, they may use I-Help to put them in contact with a group that functions effectively with regard to the particular skill. They may be invited to observe, as the efficient group models the behaviour during their next meeting, or one of the effective group members may describe how their group tackles these issues. This will be especially useful where there are no resources (e.g. time, staff) for skills training.

Again the I-Help student model must be extended, to accommodate information about group interaction skills. This will involve all groups in a group evaluation process in order that they may provide skills information for the user model, which in itself will be a useful reflective activity. The main difference in the structuring of the model in this case is that skills information will relate to *group* functioning, and not to specific group members. Thus I-Help must also know which students belong to which groups. Skills information need then only be given by one learner.

A potential difficulty encountered by a student who might otherwise do well in PBL is that other group members may have different interaction preferences: some students gain much from brainstorming or spontaneous discussion, while others prefer to reflect and organise their thoughts before communicating. The combination of face-to-face meetings and the public discussion forums helps to cater for all students, while the possibility also exists to arrange collaboration, cooperation and feedback through the private discussions.

Students also have different cognitive styles. Some individuals understand verbal descriptions well, while others need pictures, diagrams, or demonstrations. Some learners deal well with abstract concepts and detail, while others tend towards a more general overview. Although a mixture of cognitive styles might sometimes be complementary in a group setting, and have a positive effect on group performance, some cognitive style combinations may lead to difficulties for some individuals. For example, if most members of a group are analytic, a wholist learner may have difficulty gaining the overview perspective they require to integrate information. Such an individual might find the situation very difficult as a learning experience. It is also possible that the other group members will not understand their difficulty. This is a problematic situation since all group members should be involved in group communications for a group to feel comfortable and function well. Full participation is essential in some groups to avoid resentment by other group members if they feel that one person is not contributing. I-Help private discussions should not, then, be used as an alternative to group interaction, as the group may suffer as a result. However, for students who have problems adapting to the way the other group members work, I-Help may provide a much-needed 'lifeline' by matching them with a student with a similar cognitive style, to support their PBL activities in a 'more comfortable' fashion. Thus they will continue to interact with their group to the best of their ability given the difficulties they experience, but they may also work with another learner outside the group context if they feel this to be useful. This need not detract from the group experience as a whole, since the learner may report back any findings. Taking the above example, such an individual's contribution may now be greater, since they will be able to provide the overview that the analytics lack. Therefore their group contribution may be stronger than any earlier contributions where they had not had this additional learning opportunity, and were interacting only within the confines of the particular group's interaction dynamics.

This section has suggested a number of ways in which I-Help might be useful in PBL. It is not suggested that all PBL students should use it (though the public forum is likely to be generally useful), but that I-Help could arrange peer support in cases where an individual is having difficulties with some aspect of the PBL approach.

Although it does not address the problem of group learning for an individual who prefers to learn alone, or in a different kind of group situation, it does at least provide them with some support that they would otherwise not have.

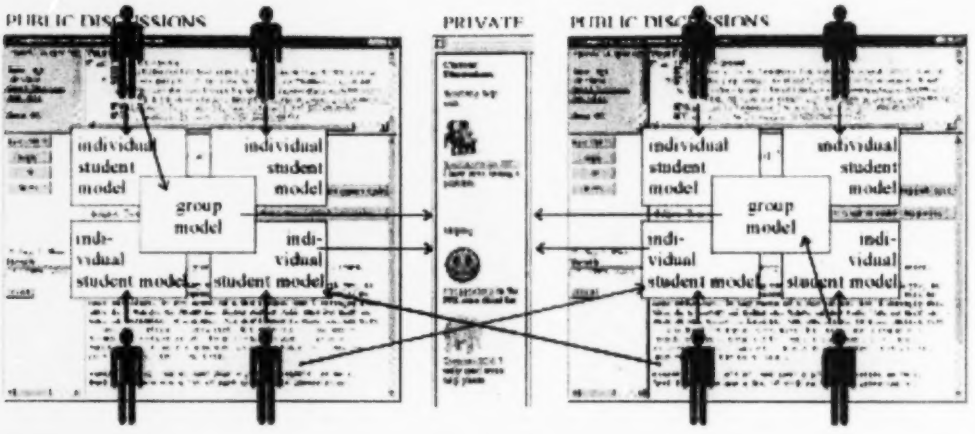

Figure 2: I-Help in problem-based learning

To introduce I-Help to the PBL setting, some additions to the user models are necessary. However, these are very easy to implement, having simplicity in common with the present representations. Currently I-Help user models contain: a quantitative measure of knowledge levels in the various domain areas; a quantitative indication of helpfulness; a quantitative measure of eagerness; a list of friends; a list of banned people; identification of cognitive style; a list of preferred interaction types. The additional information proposed above comprises: a list of roles successfully performed previously (to be added by the individual); the current role of the student (also added by the individual); a list of group membership (provided by one group member); a list of group skills (based on group evaluation, the result of which is entered by one group member). Thus minimal extensions could provide essential support to learners having difficulties in PBL. Provision of this information by students should also encourage them to think about factors that help to make group interaction successful.

Figure 2 illustrates how I-Help can support learners in a PBL setting. Students and peers provide student model information as occurs in large group uses. I-Help also performs some user modelling as described previously. The main difference with I-Help in PBL is that interactions for each group are focussed primarily around public discussions, with each person communicating with other members of their own group. There is less use of the private discussions. Where private discussions do occur, matching takes place according to the student models of individuals in the manner described in section 3. In addition to individual models, in PBL group models are required in order that groups may also be brought together where difficulties are recognised by the group as a whole. Information for the group model is obtained from one of the group members.

5 Conclusions

I-Help was initially designed to promote peer help amongst a group of learners in a large class situation. Some minor extensions to the system were suggested, to enable it to be effective also for students in PBL. Despite many successes claimed for this kind of collaborative interaction, not all students will function at their best with this type of curriculum. In this paper we focussed on PBL in medical education, but the arguments should be equally applicable to other academic disciplines and small group contexts, as long as the overall student numbers are large enough to enable sufficient choices of appropriate partners for cross-group interaction.

In addition to large and small group formal educational settings, I-Help might also be used beyond the classroom to support medical practitioners. For example, while some contexts have adequate funds to implement elaborate means of telemedicine (e.g. the U.S. Army [1]), remote areas which might benefit from access to various forms of telemedicine often find that the low population density does not provide sufficient demand to justify the expenditure required [25]. In rural locations a system like I-Help would provide a low cost means of obtaining expert help at least for some cases. Furthermore, practitioners requesting assistance do not themselves need to know who is the best person to contact. Similarly, I-Help might be useful in putting into contact physicians who

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would like to hear experiences of other practitioners. For example, where ethical considerations are important to a case, such as conflicts between medical advice and parental beliefs [7]. I-Help might also be used alongside diagnostic decision support systems in cases where physicians remain unsure about hypotheses, since the advice offered by such systems may sometimes be misleading [9]. Experience with I-Help at university should encourage more individuals to register once they graduate and specialise.

Acknowledgements

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The Interactive Virtual Community

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Because of the advanced technique of Internet, The virtual community is available and becomes popular on Internet. In this study, we focus on the interactive mechanism of a virtual community. We discuss the object-oriented interface and the environment. In the interactive virtual community, people can establish his own personalized space. He can be both system manager and user in the same time.

Keyword: **Virtual community, Interactive mechanism, Object-oriented.**

1 Introduction

Gradually, the V.C. (V.C.) is more and more popular on Internet. We firstly discuss the definition of the V.C. and the reason why it becomes popular. Most of the interfaces of the virtual communities seem too difficult for users to use. Some of them are not user-friendly. Some of them do not provide personalized features. We establish a V.C. called "Virtual University" which has the extensive mechanisms between people. We establish an interactive interface which allows the members of the V.C. communicate freely and independently.

2 The Definition of the V.C.

a. The circumstances of the V.C.: The V.C. gathers the people having same interests, inclination, favorite, or same domain to exchange information. The BBS (Bulletin Board System)can be regarded as the earliest version of the V.C.. In the chat room of Internet, users can communicate with each other on a web browser in real time. There are some famous web-site of specific topic and particular services. For example, Geocities and HotGroup supply personal homepage space, ICQ is a famous tool on internet for real-time message. More new function is added to the V.C. such as chat room, the essence board, message board, the message of searching people, etc.

b. The characteristics of the V.C.: For most of the V.C., they focus on a particular subject. They allow the members use some functions to exchange their viewpoints with others. They also encourage the members presenting their ideas and experiences. They always try their best to collect resources such as good company and the relative products to their members. And through these valuable resources and good environment, the V.C. can become a virtual company and gain profits.

The V.C. provides the users a place for communication, social contact and publishing. The user used to visit a homepage just for information. There is not any connection between visitors. But, in the V.C., people visit a web-site not only because the information but also the friends. It gathers a group of people and provides them opportunities to talk to each other. It saves the record of users and change temporal visitors into its loyal citizens. Until now, the functions of the V.C. on Internet do not make a lot of progress when being compared with BBS. For the users can't alter the environment as they like, they feel not enough emotion to participate the group as they in a real community.

3 The system framework

'The Virtual University' is not a simulation of a real college but an interactive platform. It allows users set

up any kind of subjects as they like on it. We lean three subjects in college such as 'school work', 'club' and 'love' lesson. The club lesson and love lesson are a multi-user game. New member had to register. The system shows its facilities in a map. The user adds any object to the environment according his authority. The supervisor of management just acts as an observer and the helper of users.

4 The sketch of interactive system

At present, almost web-site can only provide poor interactive function to the users. The user has no authority to reallocate the objects of the environment. He lives in a society with no right. The text-based communication always causes unnecessary misunderstanding of others. An ideal V.C. should more or less like a real society. In our system, system supervisor provides interactive objects and tools to users. Then members use these objects to build up the whole V.C.. Time and time, generation and generation, the information is extremely huge and dramatically powerful. Only the society which is controlled by users can really last long. There are three characteristics of our platform:

a. A visual Object-oriented personalized interface: Our graphic-oriented system use picture interface to show emotion and transfer message. User can have his user-ID and his picture. The picture which is constructed by user shows the user's face.

b. The user's authority to build the environment space: The society contains many sub-societies. Each sub-society has one system manager. The manager administrate manages all objects of his area and maintain the rule of the society. The user has the authority to change the environment. As Fig-1 shows, we distinguish members into two kinds. The personalized interface is here to let the member create picture of his own. The object manager system and Fuzzy system can adjust the flow of the game.

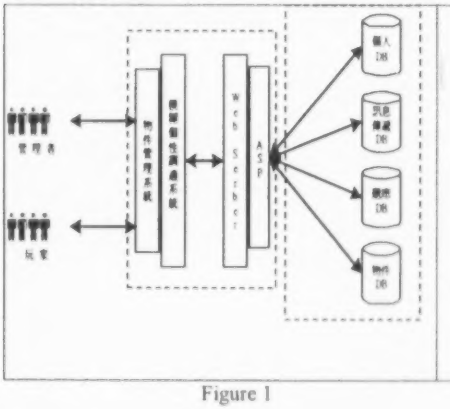

Figure 1

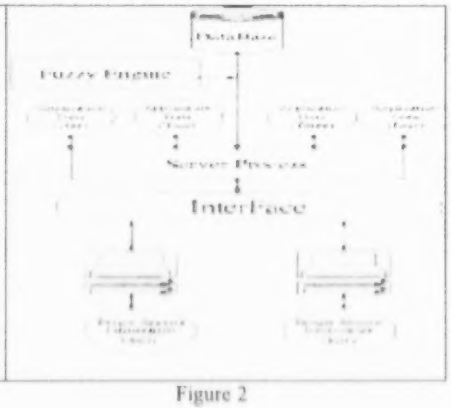

Figure 2

c. The real-time interactive communication: The game-based environment allow users travel around. The users can learn, entertainment, explore and interact with other users. As fig-2 shows, we apply ASP's(Active Server Page) Session and Application object, and adopt Fuzzy to create model.

5 Conclusion

In the future, There will be plenty of people in the V.C.. It means that will be a lot of commercial potential in the V.C.. Undoubtedly, the graphic-oriented V.C. with virtual reality will be the main stream of the market. We purposes a prototype of perfect platform of the V.C. and open ours arms welcome the leading character of the coming age - the V.C..

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The network learning supported by constructivism

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1 Introduce

Network learning gives a chance to educators to rethink and investigate the learning modules and styles. Therefore the educators can rearrange learning strategies and develop new learning environment to validate the learning strategies and ideas. Although network learning cannot affect the learning completely and fully, at least network learning offer the environment to fulfill the ideas of constructivism.

2 Setting up the network learning environment

2.1.To provide multiple and abundant materials:

The network learning resources provide the objective and existed knowledge, the multi-angle and multi-level experiences to give learners various stimulations. In other words give the learners a chance to create multiple constructions, the same learner create different level construction at distinct time.

2.2.Give learners the authentic problems:

The important mission when teachers proceed with the instruction of constructivism is to arrange and provide the abundant and fitted learning environment, to offer and assist learners to construct knowledge actively and successfully.

2.3.Encourage learners raise various solving methods for the problems:

Promote learners to think of the problems by multi-angle ways. In order to encourage learners to discuss, think, argue and learn cooperatly, thus the learning have to be proceeded with dialog and communication.

2.4.Clear learning goals and concepts:

In internet world no place is too far away to be reached. If let learners grope or learn alone, it's usually happen that learners disorientate in the internet world. Thus if there is no clear goal, learning activity will be one pattern of browse and the emphasis will be neglect. Let learning activities concentrate at the learning goals or concepts, learners will get more complete knowledge, understand the key points, thus increase learning effects.

2.5.Learners can present viewpoints fully:

The internet world is a multi-person and pluralistic environment . In addition to self-learning, learners can see the learning portfolios of others. The learners review the cognition of others by self-viewpoint, furthermore to imitate and learn the others, and self-viewpoint can also be referred by others. Learners develop one kind of self-thinking in the environment of arguing with others again and again. Thus learners are no more silencers, but the learners are encouraged to present their viewpoints or opinions.

2.6.Adaptive courses:

There are individual differences between learners, learning processes or learning strategies of learners are different from others. Thus the design of courses should be considered about the individual

difference,adapted to learning situation of learners. Arrange different course to match the learning situation and abilities of learners, thus learners got the individual learning.

3 Conclusion

It's convenient to search information and data in World Wide Web. The convenience is important factor to encourage learners to construct the self-knowledge. In the process of learners participating and learning actively, learners will feel that they have got self-learning goal.

In constructivism it's important factor that learners participate actively in learning process. Thus learners must participate self-learning activity positively. Learners should search and find knowledge what they want actively.In network learning environment the learning activities are emphasized the" internal control" directed by learners, and requesting learners to learn by their strategies in the process of learning activities.

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